The American Journal

of Surgery

CONTENTS OF NEW SERIES, VOLUME LV
ORIGINAL ARTICLES

Contents

Editorials

LEST WE FORGET

"WITH the hot blasts of hate still on our cheeks, it may seem a mockery to speak of this as the saving asset in our future; but is it not the very marrow of the teaching in which we have been brought up? At last the gospel of the right to live, and the right to live healthy, happy lives, has sunk deep into the hearts of the people; and before the war so great was the work of science in preventing untimely death that the day of Isaiah seemed at hand 'when a man's life should be more precious than fine gold, even a man than the gold of Ophir.' There is a sentence in the writings of the Father of Medicine upon which all commentators have lingered, ἦν γὰρ παρή φιλανθρωπίη, πάρεστι καὶ φιλοτεχνίη—the love of humanity associated with the love of his craft!—philanthropia and philotechnia—the joy of working joined in each one to a true love of his brother. Memorable sentence indeed, in which for the first time was coined the magic word *philanthropy*, and conveying the subtle suggestion that perhaps in this combination the longings of humanity may find their solution, and Wisdom—philosophia—at last be justified of her children."

WILLIAM OSLER.

MEDICAL MORALS AND MANNERS

"THE medical profession (or 'procession' as someone recently called it) has room always for those of character and brains who are willing to sacrifice their lives in its service. Our vocation is a profession, not a trade; a science, not a business. We want those who can realize this distinction—who know what it means to be gentlemen and to follow the golden rule, who stand as examples of sound morals and manners in the conduct of the medical life. We do not welcome those who cannot or will not live up to these standards. It will not take many more years for the general public to perceive that the endeavor to perpetuate the high mark of our calling is benefiting them as well as the profession. Whatever injures the physician injures the people. Whatever is against ethics is against the patient.

"With these ideas before us, we have nothing to fear. We care not for quackeries, isms, pathies, and the like. Let us not forget what Edmund Strudwick, the great North Carolina surgeon, said many years ago: 'Neither the apathy of friends, the cold neglect and deep injustice of legislation, nor pampered quackery and empiricism can stay its onward course. True medical science will, like the majestic oak, with-

stand the shock and storm of every opposition. It has been beautifully compared to a star, whose light, though now and then obscured by a passing cloud, will shine on forever and ever in the firmament of heaven.'"

This is a good time to review again the above paragraphs from the pen of Hubert Ashley Royster, in "Medical Morals and Manners." The medical profession is going through rough waters. No doubt, while we strive to do our all during the coming months, some misguided zealot or narrow visioned clique with a half baked panacea for all our ills will attempt to push it down our throats by propaganda or legislation. In the long run only truth and the right will be victorious. Meanwhile Doctor Royster's wise counsel should be taken to heart.

To all who read these lines we wish a Happy, Healthy and Victorious 1942.

T. S. W.

PILONIDAL SINUSES*

REVIEW OF THE LITERATURE AND REPORT OF THREE HUNDRED FIFTY CASES

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PILONIDAL sinuses present many varied problems to an interested surgeon. Though recognized for nearly a century, there still exists much confusion concerning them. The lesions are generally considered to be congenital, but their origin is not well understood or agreed upon. Clinically, they frequently go unrecognized or are misdiagnosed. There is no universally approved and accepted method of treatment and recurrences following surgery are common. Even the name, pilonidal sinus, does not meet with general approval.

The present study was undertaken to help solve some of the above problems. To accomplish this the following work was undertaken: a comprehensive review was made of the literature; serial sections of forty human embryos were studied microscopically; a detailed analysis was made of 350 case records; pathological sections of all excised tissues were microscopically examined, and a questionnaire study made primarily to determine end results in those cases in which the patients were treated.

Hodges[40] coined the term, "pilonidal" (*pilus:* hair; *nidus:* nest) in 1880, but since that time many names have been attached to this lesion. Some of the more common names are: sacral, coccygeal or sacrococcygeal infundibulum, dermoid and dermoid fistula, sinus, or cyst, posterior umbilicus, postanal dermoid, congenital dermal sinus and sacrococcygeal ecto-dermal sinus. Clinical usage has established the name pilonidal sinus or cyst over the others, notwithstanding the fact that this is a recognized misnomer, insofar as only about half of the cases present hair in the lesion.

REVIEW OF THE LITERATURE

Anderson,[1] in 1847, was apparently the first to call attention to this lesion when he reported on "Hair Extracted from an Ulcer." Warren,[100] in 1854, gave a good description of pilonidal sinuses and reported on three cases. Later he gave a more detailed description of the condition, advanced his ideas on etiology and outlined a course of treatment. Hodges[40] reviewed the previously reported cases, added one of his own and suggested the name pilonidal sinus.

During the last two decades of the last century considerable research work was done both here and abroad on the origin of these lesions. Outstanding among the pioneer workers in this field were Tourneaux and Herrmann,[95] Lannelogue,[55] and Mallory.[59] Further contributions were made by Féré,[26] Kuhn,[49] Tait,[92] Tertillion,[94] Courad,[17] and Wendelstadt.[103] In recent years the studies of Oehlecker,[66] Stone,[86] Fox,[29] and Gage[32] have been outstanding. During the past decade no less than fifty studies on this subject have been published in this country.

Origin. The work of the investigators named above showed quite conclusively that pilonidal sinuses are congenital lesions. Prior to this, Warren[13] had suggested hairs becoming "inverted upon themselves in the follicle itself" as the etiological factor. Hodges[6] was among the first to assume its congenital origin. He considered three etiological factors as essential, namely, a congenital coccygeal dimple, abundant hair development and insufficient cleanliness.

Once anatomical study of numerous embryos by serial section had convinced research workers of the congenital nature of these lesions, two main schools of thought arose as to its etiology. The first,[] as represented by Tourneux and Herrmann,[] and Mallory,[] believed that pilonidal sinuses have their origin in a remnant of the medullary canal, and that the responsible factor is an abnormality in the development of the neural canal. The second school,[] as represented by Féré,[] maintained that pilonidal sinuses are due to an infolding of the surface epithelium or a faulty coalescence of the cutaneous covering in early embryonic life. Currently Gage[] and Fox[] hold these respective views, and present excellent articles on the same in some of the more recent literature.

Two other theories regarding etiology have been proposed. Stone,[] in 1931, advanced the opinion that pilonidal sinuses resemble the preen gland found in certain species of birds and similar or analogous structures found in certain species of reptiles and mammals. More recently Kallet[] advanced the concept that pilonidal sinuses represent growths derived from an embryonic remnant of a vestigial secondary sex gland located in the sacrococcygeal region. Neither of these theories has found wide acceptance.

EMBRYOLOGIC STUDIES

An evaluation of the above theories was attempted through a study of serial sections on forty human embryos. These embryos, all from the University anatomical laboratories, ranged in size from 4 to 180 mm., crown-rump.

To understand these theories a knowledge of embryonic development is essential.[] In the normal young embryo following the appearance of the primitive streak, a fold of tissue appears on each side of the streak. These are known as the medullary folds and between them lies the so-called medullary groove. The medullary folds gradually grow in height, and as the groove between them deepens, these folds meet and gradually fuse along the midline. The medullary groove has then become the medullary canal. It is surrounded by the primitive nerve cells of the medullary or neural tube and represents the central nervous system of the full term fetus. This tube gradually becomes separated from the overlying cutaneous covering by a rapid ingrowth of mesodermal cells. The caudal end of the neural tube is prominent by the end of the first month of intrauterine life, but thereafter undergoes a progressive atrophy. (Figs. 1, 2, and 3.) Normally, it completely disappears by the time of birth.

In our study on embryos the findings of Mallory,[] Tourneux and Herrmann[] and Gage[] were corroborated. A remnant of the medullary canal was found overlying the coccyx in all the embryos examined. (Figs. 1, 2, and 3.) In the larger embryos this invariably assumed the character of a cyst-like space, lined by cells seen lining the central canal of the spinal cord. (Fig. 3.) As a rule this cyst-like structure was well separated from the skin, but in a few specimens it was found to lie very close to the skin. During the second half of fetal life, these cyst-like structures were seen to undergo a gradual atrophy, becoming not only smaller in size, but also showing a tendency to be replaced by connective tissue.

Evidence favoring the theory that pilonidal sinuses have their origin in surface epithelium defects was also found. Many of the embryos studied showed a marked

irregularity of the surface epithelium of the coccygeal region. (Fig. 3.) A few of the fetuses actually showed a marked invagina-

During a fourteen-year period covering 313,285 admissions to the University Hospital, a diagnosis of pilonidal sinus

Fig. 1. A midline sagittal section through the caudal region of a very young embryo. Along the inferior margin the terminal coccyx may be seen. Between this and the cutaneous epithelium seen along the superior margin is a large mass of dark staining tissue with an irregular channel coursing through it. This represents the canal in the medullary tube. Figure 2 demonstrates the subsequent atrophy of this tissue. In Figure 3 only a small, cyst-like space remains.

Fig. 2. A sagittal section of a 39 mm. (C.R.) embryo showing the atrophied remains of the medullary tube and canal overlying the lower sacrum and coccyx. The canal can still be traced to the last segment of the coccyx where a cystic space appears.

tion of the epithelium, similar to the cases described by Fox.[29] Incidentally, it was noted that the surface epithelium of the caudal region was frequently quite devoid of hair follicles, sebaceous glands and sweat glands. In no case did the cells lining the cyst-like structures described in the paragraph above, resemble the squamous cells of the surface epithelium. (Fig. 3.) Finally, the theories of origin dependent upon the existence of abnormal gland tissue were not corroborated as no evidence of such tissue was found.

From these findings no conclusive opinion seems justifiable. It is to be hoped that further study, particularly of serial sections of young embryos demonstrating pathological conditions in this region, will eventually disclose the exact origin of this lesion. Such a study is now being undertaken.

GENERAL CONSIDERATIONS FROM CASE RECORD STUDIES

Pilonidal sinuses are considerably more common than is generally supposed.[12,28,70]

was made in 350 cases, seventeen of which were recurrent lesions. This is an incidence of approximately 1:940.

The lesion is most commonly found in patients ranging from twenty to twenty-five years of age.[109] In this series, the average age was twenty-five years at the time of admittance. The average duration of symptoms prior to admittance was three and one-half years, hence the average age at the onset of the lesion was twenty-one and one-half years. A sudden incident rise was noted at the age of seventeen, which reached a peak at age nineteen, and remained high through the age of twenty-five. Fifty-eight per cent of the cases occurred in this age group, a finding which may in part be explained by the fact that about 30 per cent of the cases occurred among University students. After twenty-five years of age there was a definite and maintained drop in incidence. The oldest patient was sixty-seven years of age, the youngest a newborn infant.

Pilonidal sinuses are more common in males. Of the 350 cases, 258, or 73.7 per cent, occurred in males; 92 cases, or 26.3 per cent, occurred in females. This is in agreement with the findings usually re-

ported,[110] although Newell[1] showed a predominence in females. No adequate explanation for this observation has ever

FIG. 3. A midline sagittal section of 160 mm. (C.R.) embryo showing the cyst-like remains of the medullary canal which overlies the coccyx. The epithelial cells lining this cyst cavity differ markedly in both structure and arrangement from those seen on the surface skin. There is a marked irregularity of the surface epithelium.

been offered. Conceivably, the amount of body hair might be a factor, males generally having more than females. Most men[54,69] are of the opinion that this lesion is most common in individuals having an excessive amount of body hair. However, the sinus is often seen in individuals not of this habitus.

A correlation between the age and sex incidence shows that females develop symptoms of this lesion earlier in life than the males. While 40 per cent of the females were under twenty years of age, only 19 per cent of the males were in this age group. (Table 1.) This fact, not previously reported, apparently has an etiological significance. Since the human female reaches puberty earlier in life than does the male, it appears that these lesions are stirred on to activity by the sex hormones. The rôle these hormones play in regulating body growth in general and, particularly, growth in body hair and secondary skin structures, is well recognized.

It is apparently a well established fact that this disease is strikingly restricted to the Caucasian race,[69] and our findings tend

to confirm this view. Occasional cases have been reported in negroes.[12,25,45,76,81] One of the patients in this series was a negress. No cases have been reported occurring in a member of the brown, yellow or red race. Why this should be the case is also unexplainable at the present time, although it is probable that no systematic study of sufficient numbers of these peoples has yet been undertaken.

An analysis of the nationality of the patients showed no correlation with the occurrence of pilonidal sinus. Likewise, there was no apparent correlation with the type of occupation.

A questionnaire study of the family history in one hundred representative cases revealed a hereditary factor in 10 per cent. Of these, one patient reported a similar lesion in his father, one in a cousin, seven in a brother and one in both a brother and sister. Although some authors[12,25] deny a hereditary factor, there have been many reports of a positive familial history for this anomaly.[111] Stone,[55] in his original article, cited a father and his two sons who were afflicted with pilonidal sinuses. A similar case has recently been called to the author's attention. Kallet[44] reported a case in which two brothers and one sister had this lesion. Mechling,[61] and more recently, Goldberg and Bloomenthal,[76] have reported the presence of these lesions in identical twins. These facts definitely point to an hereditary etiological factor and indicate an "anlage" for this defect in the very earliest stages of embryonic development.

By means of the questionnaire, it was also determined that 32 per cent of the cases gave a definite history of trauma, usually either a fall or a blow. (Table 11.) Analysis disclosed, however, that in only 14 per cent did the trauma occur within a month of the onset of symptoms. In nearly half of the cases, the alleged injury occurred from one to ten years previously. It seems unlikely that any injury occurring more than one month prior to the onset of symptoms could be considered as an

aggravating factor. On this basis 86 per cent of the patients presented no history of significant injury. Although contrary

slow healing lesions, was found in but four cases (1.2 per cent). There were six cases (1.8 per cent) of pulmonary tuberculosis,

TABLE I
INCIDENCE IN RELATION TO SEX AND AGE

	Age in years	0 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	31 to 35	36 to 40	41 to 45	46 & over	Total
MALES	No. of cases	7	0	2	60	103	31	25	7	13	10	258
	Per cent of total	2.7	0.0	0.8	23.2	40.0	12.0	9.7	2.7	5 0	3.9	73 7
	Cumulative per cent	2.7	2.7	3.5	26.7	66.7	78.7	88.4	91.1	96.1	100	
FEMALES	No. of cases	7	0	3	31	23	12	5	6	2	3	92
	Per cent of total	7.6	0.0	3.3	33.7	25.0	13.0	5.4	6.6	2.2	3 2	26.3
	Cumulative per cent	7.6	7.6	10.9	44.6	69.6	82.6	88.0	94.6	96.8	100	

Average age of group.................................... 24.9 yr. (350 cases)
Average age of males.................................... 25.47 yr. (258 cases or 73.7 per cent)
Average age of females....... .... 23.26 yr. (92 cases or 26.3 per cent)

to the generally accepted view,[112] it seems justifiable to conclude that direct trauma plays a comparatively minor rôle in the etiology of pilonidal sinuses. Weinstein,[101] and Breidenbach and Wilson[12] share this view. Indirect trauma such as friction incidental to sitting, or the irritation of clothing, is thought to play an etiological rôle by Zieman.[106]

A study of associated and incidental diseases proved interesting. Kallet[45] recently suggested that the pituitary gland may play a rôle in pilonidal sinus development, but there was only one case of pituitary disease (acromegaly) recognized in this series. Johnson and Livingston,[42] have reported a high incidence (3.4 per cent) in a study of 1,000 mental defectives; but in our series there were only four cases (1.2 per cent) with associated mental disorders. Associated congenital defects were recognized in six patients (1.8 per cent) with skeletal abnormality, (four were spina bifidas), and there were four cases (1.2 per cent) with inguinal hernias. Diabetes, a disease often associated with

and one case (0.3 per cent) of bone tuberculosis. Only three patients (0.9 per cent) had syphilis. Apparently, pilonidal sinuses do not play an active rôle as foci of infection. There were seven cases (2.1 per cent) with an associated hypertension, three cases of nephritis (0.9 per cent), three cases of arthritis (0.9 per cent) and two cases of furunculosis (0.6 per cent).

CLINICAL MANIFESTATIONS

Symptoms. The average duration of symptoms from the onset until the time of admission was thirty-eight months for this series. The duration of symptoms varied directly with the age of the patients. Thus, the average duration in patients under twenty years of age was sixteen months; in patients from twenty to thirty years of age, it was thirty-eight months; while in those over thirty years of age it ranged from five to twenty years or more. (Table III.)

There is a general agreement as to the signs and symptoms produced by pilonidal sinuses and the findings of this series are

typical. (Table IV.) Two symptoms were outstanding, namely, pain in the sacrococcygeal region and discharge. Pain was present in 84 per cent of the cases. The pain was usually mild, gnawing in character with exacerbations and remissions being

or creamy and minimal in amount, producing only a light soiling of the clothing. In three cases the discharge was blood-tinged, in two of these for prolonged periods. Rarely was a patient seen complaining only of an unexplained discharge or a

TABLE II
INTERVAL BETWEEN INJURY AND ONSET OF TROUBLE

	No. of Cases	Per cent of Trauma	Per cent of Total Cases
One day to one week....	10	31	10
One week to one month..	4	13	4
Six months to one year...	6	19	6
One year to two years...	2	6	2
Three years through five years...............	3	9	3
Five years to ten years and over...........	7	22	7
Totals.............	32	100	32

TABLE IV
SYMPTOMS

	No. of Cases	Percentage of Total
1. Tumor and pain.............	27	9
2. Tumor, pain and discharge.....	151	51
3. Pain only....................	11	4
4. Pain and discharge......	56	18
5. Discharge only................	27	9
6. Chills and fever and painful mass	5	2
7. Tumor only.................	3	1
8. Itch only....................	3	1
9. Symptomless	16	5

Total number of patients with pain 250 (84 per cent). Total number of patients with discharge 234 (78 per cent).

common. Often there was only discomfort on sitting. The exacerbations were associated with recurrent infection and abscess formation. In several female patients the pain was worse at the time of the menses, a fact which may be explained on a hormonal

painless swelling in this region. Chills and fever were rarely noted.

The presenting complaint was usually "a boil over the end of the spine." Many

TABLE III
DURATION OF SYMPTOMS PRIOR TO ADMISSION

	No. of Cases	Per Cent of Total
Within one week.................	6	2.1
Two weeks to one month........	13	4.7
One to three months...........	17	6.5
Three to six months.............	30	10.8
Six months to one year inclusive...	46	16.6
One to two years................	40	14.5
Two to four years................	50	18.1
Five through eight years..........	42	15.2
Eight through twelve years.......	19	6.9
Thirteen to twenty years........	10	3.6
Twenty-one to twenty-six years...	3	1.0
Totals.....................	276	100

TABLE V
PREVIOUS OPERATIVE PROCEDURES
(117 Cases)

	No. of Operations in Outside Hospitals		No. of Operations in This Hospital		Total Operations
	I and D	Excision	I and D	Excision	
Previous operations in outside hospitals .	118	22	..	..	140 (83 cases)
Previous operations in this hospital only. .	...	..	18	10	28 (23 cases)
Previous operations both inside and outside...	16	3	9	5	33 (11 cases)
Totals.	134	25	27	15	201

basis but more likely was due to irritation from a sanitary belt. A history of a discharge was present in 78 per cent of the cases. This was usually watery, colorless

times this was a recurrent lesion. It was this history of recurrent abscesses in the sacrococcygeal region which was almost diagnostic.[81]

Of the 202 patients who underwent treatment at the University hospital, 117 (58 per cent) had undergone previous operative procedures, four out of five of these elsewhere. (Table v.) A single previous incision

TABLE VI
SIGNS

	No. of Cases	Percentage of Total
1. Abscess and sinus (es).........	81	26
2. Dimpling only...............	8	3
3. Dry sinus (es)...............	48	15
4. Sinus, discharge and hair.......	10	3
5. Discharging sinus (es).........	143	46
6. Swelling only.................	14	5
7. Inflammation and tenderness...	3	1
8. Scarring only...............	3	1

where. (Table v.) A single previous incision and drainage had been carried out in forty-nine cases, and two to four previous incisions and drainages in forty-four cases. A single previous excision had been performed in thirty cases, and two previous excisions in five cases.

Signs. Two outstanding signs were abscess formation and the presence of a sinus in the sacrococcygeal region. (Table vi.) Abscesses occurred in 70 per cent of the cases. These varied considerably in size ranging from ½ to 15 cm. in the longitudinal direction. They were usually found in the deeper soft tissues overlying the coccyx and lower sacrum. The presence of one or more associated midline sinuses proved diagnostic.

Sinuses were found in 90 per cent of the cases studied. (Table vii.) Four out of five of these were single and occurred in the midline, 2 cm. or more above the anus. The remaining cases showed multiple sinuses, either in the midline only, or associated with lateral sinuses (10 per cent). The midline sinuses were, as a rule, not indurated, and had an epithelial lining. The lateral sinuses, were twice as common on the left side, and unlike the midline sinuses they showed a border of granulation tissue. Often there was an associated discharge

which was usually seropurulent in character. In an occasional case hair was seen protruding from the sinus. On probing, the sinuses were invariably found to run

TABLE VII
PILONIDAL SINUSES (282 OUT OF 310 CASES—90 PER CENT)

	No. of Cases	Per Cent of Total
One midline sinus only...........	227	80
Multiple midline sinuses only (one to five in number).............	31	11
Lateral sinuses along with midline sinuses (one to five in number)..	24	9
a. One lateral sinus with one to five midline sinuses (21 cases)		
b. Two lateral sinuses with one to two midline sinuses (3 cases)		
Totals.......................	282	100

Twenty-eight cases presented no apparent sinuses (10 per cent).

cephalad and usually they communicated with the abscesses. Multiple sinuses were commonly found to communicate with the

TABLE VIII
OPERATIVE PROCEDURES

Treatment Used	No. of Cases Treated	Average Number of Days in Hospital	Percentage of Treated Cases	Percentage of Excision Cases
Incision and drainage.	30	4.3	15.0	
Incision and drainage plus sclerosing solution...........	3	4.3	1.5	
Excision and packing ..	39	10.3	19.3	23.1
Excision, partial closure and packing.	21	11.6	10.3	12.4
Excision and primary closure............	42	10.1	20.7	24.8
Excision and closure plus drainage........	64	10.6	31.7	37.9
Excision and closure with later open packing.................	3	14.0	1.5	1.8
Totals...	202	9.5	100.0 (202 cases)	100.0 (169 cases)

same cavity, although occasionally they apparently communicated with separate cystic cavities. In about 10 per cent of

the cases there was no sinus demonstrable —true pilonidal cysts.

It is rare that a sinus occurs at a spinal

FIG. 4. Microphotograph of a typical pilonidal sinus. The epithelium lining the sinus is well preserved, and opens on to the skin surface in the upper right hand corner. In the lower left hand corner is seen granulation and scar tissue with a great many dead hairs embedded in it. This represents the deeper cystic portion of the sinus which has completely lost its original epithelium.

level higher than the sacrococcygeal. When this occurs the lesion is serious insofar as the sinus then commonly communicates with the spinal canal. Fourteen of such cases have been reported.[113] Infection of these sinuses usually results in signs and symptoms of either a meningitis or a subdural abscess. One case in the present series, previously reported by the author,[48] occurred over the third dorsal vertebra and presented the signs and symptoms of a cord tumor. At operation the lesion was found actually to invade the spinal cord.

Laboratory Procedures. Routine blood studies were usually of little value. Leucocytosis was observed only in case of acute abscess formation. There were only eighteen cases with a white blood count over

10,000 and the average for this group was 14,300. No significant findings were made on urinalysis. Bacteriological ex-

FIG. 5. Microphotograph of a pilonidal sinus demonstrating its branching. Two cyst spaces lined by epithelium are seen, and in succeeding sections these fused. Much scar tissue and inflammatory reaction is noted about the cyst spaces. Dead hairs are found lying within both the sinuses and in the epithelium proper of the cyst to the right.

amination of the discharge was carried out on only five cases. The cultures showed Streptococcus hemolyticus and Staphylococcus aureus in two cases, Streptococcus hemolyticus and a diphtheroid in one case, Streptococcus non-hemolyticus in one case, and a Gram-negative coccus in one case.

Roentgen examination following the injection of iodized oil into the sinus was resorted to in several cases. This was used to determine the extent, direction and communications of the sinus tract in certain complicated cases.

PATHOLOGY

A microscopic examination made on 170 specimens removed surgically revealed much interesting data. The sinus or sinuses usually communicated with a deeper por-

tion which showed a cystic dilatation, and the whole structure was lined by a stratified squamous epithelium. (Fig. 4.) Not infrequently the sinuses appeared to be branched, and ramifications of the irregular cyst surface were noted. (Fig. 5.) Infection and inflammation are generally noted on pathological examination.[20,41,60] The sections of this series were no exception and showed polymorphonuclear leucocytes, lymphocytes and plasma cells in varying proportions. As a result of the infection much of the lining epithelium of the cystic part was destroyed, and granulation tissue and scar tissue was seen replacing it. Occasionally, small islands of regenerating epithelium were seen. Hair was found in the cystic cavity or in the granulation tissue in eighty-nine of the sections studied (52 per cent). Usually the hair was dead and of a fine texture, but hair follicles were noted in fifteen cases (9 per cent), most commonly on the sinus proper. Because some authors[12,52] deny the presence of sebaceous and sweat glands in the deeper tissue, a careful search was made for the same. Sebaceous glands definitely related to the cyst or sinus were demonstrated in five of the tissues studied (Fig. 6); sweat glands thought to be related to the lesion were also seen. Granulation tissue devoid of epithelium, hair or accessory skin structures was seen in sixty-six cases (39 per cent). Foreign body giant cells, indicating tissue reaction, were seen in 44 per cent of the cases. These were most commonly found in the granulation tissue, frequently about dead hairs and on a few occasions about old suture material.

A study made of the pathological sections of those cases in which two or more excisions were done proved of interest. Of twelve cases examined all but one demonstrated typical pilonidal sinus tissue. In nine of the remaining eleven cases, dead hair was found in the granulation tissue removed from within the wound. This is interpreted to indicate incomplete removal of the lesion at the time of the first operation.

A careful study of all the available sections failed to reveal any trace of glial tissue or embryonic nervous tissue remains.
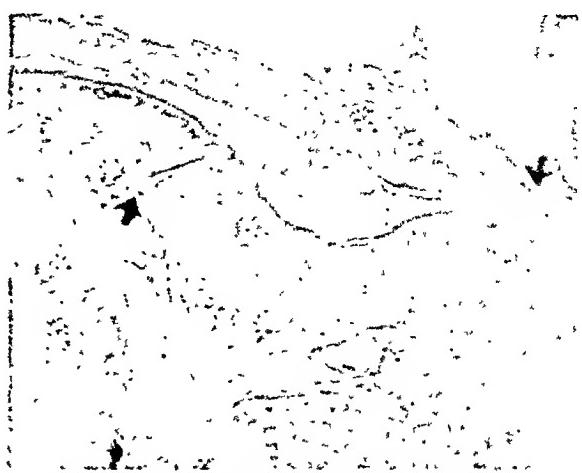
FIG. 6. Microphotograph of a fairly well preserved pilonidal sinus showing a minimum amount of infection. To the left a typical hair follicle with an associated sebaceous gland is seen, while on the extreme right, further sebaceous gland tissue associated with the same sinus is noted. Two arrows have been placed to indicate these areas. Within the sinus proper, some epithelial debris and a few dead hairs are seen.

Gage[31] reports its presence in one case and ascribes great significance to it etiologically.

DIAGNOSIS

The diagnosis of pilonidal sinus is usually not difficult. The history of recurring pain and discomfort in the sacrococcygeal region, frequently with a discharge, is very suggestive. The presence of a lump or abscess in this region should call to mind this lesion. A careful search will usually reveal one or more characteristic midline sinuses lined by epithelium, and varying in size from 1 mm. up to 1 cm. or more in diameter. Hair will occasionally be seen protruding from the sinuses. One or more lateral sinuses may also be noted, but these will be lined by granulation tissue. Discharge from any or all the sinuses is common. Finally, it should be noted that the midline sinuses course a cephalad direction when probed.

In a differential diagnosis a number of pathological conditions must be considered. Fistula-in-ano can be recognized by the caudad direction of its sinus when

probed and by identifying the mouth of the sinus on rectal examination. Furuncles, boils and carbuncles neither give the prolonged history nor that of repeated attacks at a given site; they do not have epithelial sinuses and usually lie more superficially. Plugged sebaceous follicles likewise are also more shallow. Osteomyelitis, tuberculosis and syphilis should be ruled out through history, serology tests and x-ray examination. Traumatic dermoids and implantation cysts should be differentiated by a careful history and physical examination. Chordomas, terratomas, fetal adenomas and other neoplasms may have to be considered. If a careful history and physical examination with x-rays do not differentiate them, a biopsy should be taken. In rare cases roentgenograms, taken after the injection of an iodized oil, will prove most helpful diagnostically.[2,11,69,78]

TREATMENT

It is obvious from pathology that any form of treatment, to be successful, must completely eradicate the cyst or sinus and all the granulation tissue. Furthermore, it must control the infection during the process of healing. There still exists a great diversity of opinion as to how this may best be accomplished, and no single method of treatment has proved satisfactory. Unsatisfactory end results, usually due to either delayed healing or a recurrence of the lesion, remain a problem.

Many ambulatory methods of treatment have been suggested. These generally aim to destroy the diseased tissue either through the medium of chemicals or by means of electrical currents. Anderson[2] injected chloride of mercury. Crookall[18] used caustic silver nitrate. Cutler and Zollinger,[20] and later Block and Greene[8] report on the efficacy of a modified Carnoy's solution. Recently Biegeleisen[6] introduced fuming nitric acid. Maillard[58] first used electricity to effect a cure. Rogers and Hall[75] and more recently Rogers and Dwight[74] have reported gratifying results in two large series of cases treated by

excision with cautery followed by open packing.

The great majority of surgeons favor hospitalization in the treatment of this condition. Incision and drainage is generally considered the treatment of choice in cases showing acute infection. Excision is advised when the infection has subsided. Lahey,[52] Cattell,[13] Ferguson,[25] Colp,[16] Horsley,[41] and others[91-104] have advised special technics of primary closure. A large group of men prefer excision and primary closure.[114] Some men advocate primary closure with a drain, and La Rochelle[56] has advanced a special technic for this. Weeder[102] suggests this method of treatment but believes that in selected cases the coccyx should be removed to obviate recurrence. Probably the great majority of surgeons[115] believe that excision and packing of the wound, either with or without partial closure, constitutes the treatment of choice for most cases.

Analysis of Treatment in This Series. Treatment was rendered in 202 of the 350 cases diagnosed. A general anesthetic was used in the great majority (over 90 per cent) of these patients, while a spinal agent was used on only two patients. Local infiltration was used in eleven of the more simple procedures. There were no anesthetic or surgical deaths.

An analysis of the operative procedures used is seen in Table VIII. Incision and drainage, one or more times, was employed in all cases showing acute infection. It was used on thirty cases not only to afford the patient relief but also to prepare the case for subsequent curative surgery. Carnoy's solution was used in three additional cases having only incision and drainage. The results with it were encouraging, but the method was not given a sufficient trial to warrant a full evaluation of this type of therapy. Its use in the less complicated cases seems desirable.[8,20,81,98]

Excision of the lesion was employed in 169 cases. Closure of the wound, either with or without drainage, was limited to the more mildly infected cases (63 per

cent), while the remainder were "packed open," some with partial closure. A colored solution, such as methylene blue, was used preoperatively in sixty-three of the cases. On twenty occasions the excision was done with a cautery knife. Most of the excisions were accomplished by means of an elliptical incision over the diseased area, although special technics were resorted to occasionally. Obliteration of all "dead space" was considered to be of the greatest importance in all wounds that were closed. If this was not feasible, the wound was treated by

this was used in conjunction with other treatment in two cases. No advantages, other than relief of discomfort, could be demonstrated from any of these procedures.

The average stay in the hospital (Table VIII) for the group treated by excision was ten and one-half days; the patients treated by primary closure averaged 10.4 days, compared to 10.7 days for the "open" group. It was noteworthy that the patients on whom either methylene blue or cautery was used required 11.3 days hospitalization, as compared to 9.8 days for those on

TABLE IX
END RESULTS FOLLOWING EXCISION
(Answers per Questionnaire Method)

Type of Treatment	Total No. of Cases	Days from Work*	Days of Dress-ings*	Patients Cured	Per Cent Cured	Per Cent Non-cured
Excision and packing	24	6	90	19	79	21
Excision and partial closure	10	23	66	8	80	20
Excision and closure later open packing	2	0	94	1	50	50
Excision and primary closure	24	2	26	19	79	21
Excision and primary closure with drain	29	8	28	19	66	34
Averages	(89 cases)	7	50	(66 cases)	74	26

Total number treated by packing was 36 cases: 28 cures (78 per cent).
Total number treated by closed method was 53 cases: 38 cures (72 per cent).
  * Average number of days after leaving hospital.

an open method. In every case an attempt was made to eradicate completely the diseased tissue, usually exposing the fascia over the sacrum and coccyx. In no case did the disease seem to involve the coccyx. Although cases have been reported in which the sinus extended to within the sacral canal,[33,62,72,106] none were found in this series. Spinal fluid was encountered only in the case occurring over the third dorsal vertebra, previously referred to.[48] Lesions extending down to and around the anus have occasionally been reported.[22,82,88,98,106] Although they rarely involve the anus, one case in this series had an associated anal fistula.

Postoperative treatment on protracted cases frequently included daily hot Sitz baths. Bakes were occasionally used. Smith[83] has suggested x-ray therapy and

whom neither of these procedures was employed.

END RESULTS

The end results of curative surgery for pilonidal sinuses leave something to be desired. A prolonged healing time and recurrences, have been responsible for dissatisfaction with the results. In the present series replies to a questionnaire were received from eighty-nine patients who had undergone an excision of the lesion. The end results are shown in Table IX and are typical of those generally reported.[116] There was a "permanent cure" reported in 74 per cent of the cases, 72 per cent for the group treated by primary closure, and 78 per cent for the cases with open packing.

In Table IX the morbidity findings incidental to excision of the lesion are shown. The average period of incapacitation after leaving the hospital was seven days, six days for the patients treated by primary closure and ten days for open packed group. Only 18 per cent of the patients were incapacitated and the average period of further time away from work was five weeks. These cases represented 9 per cent of the "cured" group, as compared to 43 per cent of the "noncured;" the former averaged three days of further incapacitation and the latter twenty-five days.

All of the patients, excepting two who were treated by primary closure, required further dressings after leaving the hospital. The average healing time was fifty days, forty-five days for the cured cases as compared to seventy-two days for the noncured. The wounds of those treated by primary closure healed about three times as fast as those packed open: twenty-seven and eighty-four days, respectively.

A residual discomfort or pain at the site of operation was reported by 28 per cent of the patients who claimed a permanent cure following excision. Exactly two out of three in the "noncured" group experienced the same—an average of 36 per cent for the entire series. This discomfort and pain was twice as common in the patients treated by primary closure as in the open packed cases.

An analysis of the twenty-three non-cured cases showed eighteen patients who stated they had a complete recurrence of the lesion, three who stated they had only mild symptoms, and one whose wound "never healed." The interval between time of operation and onset of further trouble averaged twenty months. A third of these patients experienced symptoms within a month and two-thirds within a year. In three cases the time interval was over five years. The symptoms were identical to those present preoperatively, namely, pain and discharge, discharge only, and pain only, in order of their frequency. Eleven of

these patients were apparently ultimately cured, four with conservative treatment, one following incision and drainage, and five following a re-excision of the lesion. The remaining twelve patients were not symptom free at the time of the questionnaire, notwithstanding the fact that two of them had undergone a subsequent incision and drainage, and three had undergone one or more re-excision operations elsewhere.

Dunphy[23] has shown that the choice of suture material in pilonidal surgery is important. An analysis of the questionnaire cases with respect to this disclosed fifty-eight cases with known suture material, representing forty-two cures and sixteen noncures. The latter group can be augmented by nine patients who were re-operated upon in which the suture material was known at the time of their first operation. The totals then show nineteen failures in forty-two cases (45 per cent) in which catgut was used in the deep tissues, as compared to six failures in twenty-five cases (24 per cent) in which silk was used. These findings corroborate those of Dunphy, and the use of nonabsorbable suture material is advised.

Preoperative injection of methylene blue is recommended by some authors[117] and condemned by others.[12,73,80,105] The latter maintain that the operator frequently gets a false sense of security insofar as some channels are occluded and will not show the stain, that normal tissue may become stained, and that excision of this tissue will prove harmful because of the larger defect produced thereby. A study of the questionnaire cases with respect to the value of methylene blue injection showed that it was used in forty cases, ten patients of which were not cured (25 per cent). In the remaining forty-nine cases, in which no dye was used, there were thirteen noncures (29 per cent). To evaluate this problem further a group of thirteen patients re-operated upon can be added to the twenty-three noncures listed above. The results then show twenty-two failures in fifty-eight cases, (38 per cent) noncures in which no

dye was used, as compared to fourteen failures in forty-four cases, or 32 per cent noncures in which the dye was used. These data appear inconclusive but favor the school which recommends the preoperative injection of a dye to delineate the lesion.

SUMMARY AND CONCLUSIONS

1. The various theories on the origin of pilonidal sinuses are presented. The findings of a microscopic study of serial sections on forty human embryos are also presented. It definitely is a congenital anomaly, either of ectodermal or neural canal origin. The evidence is not conclusive in this respect.

2. The 350 cases studied represented an incidence of roughly 1:1,000. It is more common in males than in females and strikingly confined to the Caucasian race.

3. The defect usually manifests itself during the second and third decade of life. Females suffer earlier in life than males, a fact which apparently has etiological significance.

4. A positive hereditary factor is found suggesting an "anlage" for this defect in very early embryonic life.

5. Direct trauma plays a comparatively minor etiological rôle.

6. Pain and discharge are the predominating symptoms and are due to infection. Recurrent abscesses and one or more draining midline sinuses in the sacrococcygeal region are usually noted.

7. The pathological picture is that of a dermal sinus containing hair in about one-half of the cases. All of the sections showed evidence of either an acute or a chronic inflammation.

8. The diagnostic criteria are presented; diagnosis is usually simple.

9. Treatment remains an individualized problem. Incision and drainage is indicated in all cases of acute infection. Carnoy's solution following incision has merit in selected cases. Excision with primary closure is advisable in the comparatively uninfected and less extensive lesions. Excision and open packing is indicated in the more severe and recurrent lesions.

10. The end results of all methods of treatment leave something to be desired. A prolonged healing time and recurrence of the lesion are common problems.

11. The suture material used in the closure of wounds is important; silk is preferable to catgut.

12. Methylene blue used to delineate the lesion is recommended.

REFERENCES

1. ANDERSON, A. W. Hair extracted from an ulcer. *Boston M. & S. J.*, 36: 74, 1847.
2. ANDERSON, J. K. Diagnosis and treatment of pilonidal sinus. *Minnesota Med.*, 14: 421–424, 1931.
3. BALLANTYNE, E. N. Sacrococcygeal tumors, adenocarcinoma of cystic congenital embryonal remnant. *Arch. Path.*, 14: 1–9, 1932.
4. BATEMAN, E. J. Congenital tumors of the coccygeal region, *Ann. Surg.*, 80: 834, 1924.
5. BECK, E. G. Infected dermoid sacral cyst; excision; no suture; skin regeneration aided with adhesive strips. *Internat. Clin.*, 31: 32, 1921.
6. BIEGELEISEN, H. I. Sclerotherapy for pilonidal cyst. *Am. J. Surg.*, 44: 622–625, 1939.
7. BLAND-SUTTON, J. Dermoids. London, 1889. Baillière, Tindall & Cox.
8. BLOCK, L. H. and GREENE, B. L. Pilonidal sinus; sclerosing method of treatment. *Arch. Surg.*, 37: 112–122, 1938.
9. BOLDREY, E. B. and ELVIDGE, A. R. Dermoid cysts of the vertebral canal. *Ann. Surg.*, 110: 273, 1939.
10. BOOKMAN, M. R. Treatment of sacro-coccygeal sinus (pilonidal sinus). *New York State J. Med.*, 24: 204, 1924.
11. BRAMS, J. Injection of pilonidal cyst with lipiodol. *Radiology*, 8: 248–249, 1927.
12. BREIDENBACH, L. and WILSON, H. L. Pilonidal cysts and sinuses. *Ann. Surg.*, 102: 455–463, 1935.
13. CATTELL, R. B. Technic of operation for pilonidal sinus. *S. Clin. North America*, 14: 1289–1293, 1934.
14. CATTELL, R. B. and STELLER, L. W. The treatment of pilonidal sinus and end results. *New England J. Med.*, 206: 110, 1932.

15. CLARK, S. N. Report of a case of spina bifida occulta in cervical region. J. Nerv. & Ment. Dis., 48: 201–205, 1918.

16. COLP, R. Treatment of pilonidal cyst; and fistula. Surg. Clin. N. America, 9: 695–700, 1929.

17. COURAD, J. Dépressions fistules congénitales cutanées, Thesis for Doctor of Medicine. Faculté de Médecine de Paris, Paris, p. 262, 1883.

18. CROOKALL, A. Preliminary report on the treatment of pilonidal sinus with silver nitrate. Tr. Am. Proct. Soc., 28: 32, 1927.

19. CUPP, H. B. Pilonidal sinus. M. Bull. Vet. Admin., 15: 291–293, 1939.

20. CUTLER, E. C. and ZOLLINGER, R. The use of sclerosing solutions in the treatment of cysts and fistulae. Am. J. Surg., 19: 411, 1933.

21. DELAFIELD, F. and PRUDDEN, T. M. Text-book of Pathology. 16th ed., page 1209. Baltimore, 1936. Wm. Wood & Co.

22. DRUECK, C. J. Post rectal tumors. Am. J. Surg., 39: 247–249, 1925.

23. DUNPHY, J. E. The operative treatment of pilonidal sinus. Surgery, 2: 581, 1937.

24. EISBERG, H. B. Pilonidal sinus. Am. Med., 35: 152–154, 1929.

25. FANSLER, W. A. and ANDERSON, J. K. Case of pilonidal sinus in a negro. Minnesota Med., 17: 146, 1934.

26. FÉRÉ. Bull de la Soc. Anat. de Paris, 4 Série, 3: 309, 1878.

27. FERGUSON, L. K. Pilonidal cysts. Ann. Surg., 101: 469, 1935.

28. FERGUSON, L. K. and McCRAY, P. M., JR. Pilonidal cysts; excision and primary suture in ambulatory patients. Am. J. Surg., 36: 270, 1937.

29. FOX, S. L. The origin of pilonidal sinus. Surg., Gynec. & Obst., 60: 137, 1935.

30. GAGE, M. Pilonidal sinus. Arch. Surg., 31: 175, 1935.

31. GAGE, M. Pilonidal sinus. New Orleans M. & S. J., 89: 13–17, 1936.

32. GAGE, M. Pilonidal sinus. Internat. Clin., 3: 19–32, 1936.

33. GAGE, M. Pilonidal sinus, sacro-coccygeal ectodermal cysts and sinuses. Tr. South. S. A., 50: 52–71, 1937.

34. GAGE, M. Pilonidal sinus. Ann. Surg., 109: 291, 1939.

35. GLENN, F. Review of 120 cases. New England J. Med., 207: 544, 1932.

36. GOLDBERG, S. L. and BLOOMENTHAL, E. D. Pilonidal sinuses in identical twins. J. A. M. A., 113: 1401, 1939.

37. GOODSALL, D. H. and MILES, W. E. Diseases of the Anus and Rectum. London, 1900. Longman's Green & Co.

38. HAMBY, W. B. Pilonidal cysts, spina bifida occulta and bifid spinal cord. Arch. Path., 21: 831–838, 1936.

39. HAYTER, H. M. Pilonidal sinus. Virginia M. Monthly, 54: 447–449, 1927.

40. HODGES, R. M. Pilonidal sinus. Boston M. & S. J., 103: 485, 1880.

41. HORSLEY, G. W. Pilonidal sinus. Virginia M. Monthly, 60: 104–107, 1933.

42. JOHNSON, W. J. and LIVINGSTON, A. G. Pilonidal sinus—incidence in mental defectives. J. Nerv. & Ment. Dis., 87: 156–158, 1938.

43. JONES, H. W. Pilonidal sinus. New York State J. Med., 27: 845, 1927.

44. KALLET, H. I. Pilonidal sinus—the factor of adolescence. Tr. Am. Proct. Soc., 37: 163, 1936.

45. KALLET, H. I. Pilonidal sinus. Am. J. Surg., 50: 648, 1940.

46. KEIBAL, F. and MALL, F. P. Human Embryology. Vol. 2, pp. 56–57. Philadelphia, 1912, J. B. Lippincott & Co.

47. KLECKNER, M. S. Pilonidal sinus, its surgical management. Tr. Am. Proc. Soc., 37: 166, 1936.

48. KOOISTRA, H. P. Pilonidal sinuses occurring over the higher spinal segments with report of a case involving the spinal cord. In publication.

49. KUHN, F. A. Bulletin Soc. de chirurgie de Paris— Paris, 2 serie 7–8, p. 319, 1867.

50. KUHN, F. A. Bull. société de chir. de Paris, 2: 334, 1867.

51. KUNITOMO, K. The development and reduction of the tail and of the caudal end of the spinal cord. Embryology, 26: 167, 1918.

52. LAHEY, F. H. An operation for pilonidal sinus. Surg., Gynec. & Obst., 48: 109, 1929.

53. LAHEY, F. H. A further suggestion for the operative treatment of pilonidal sinuses. Surg., Gynec. & Obst., 54: 521–523, 1932.

54. LAMADRID, J. J. Phila. Med. Times, 3: 699, 1873.

55. LANNELONGUE. Bull. et mém. Soc. de chir de Paris, 8: 185, 1882.

56. LAROCHELLE, F. D. An operation for pilonidal sinus. Clin. Med., 38: 244–246, 1931.

57. LOCKHART-MUMMERY, J. P. Brit. M. J., 7: 807, 1921.

58. MAILLARD, E. R. Nonsurgical treatment of a pilonidal cyst. J. A. M. A., 43: 1383, 1929.

59. MALLORY, F. B. Sacro-coccygeal dimples, sinuses, and cysts. Am. J. M. Sc., 103: 263, 1892.

60. MASSON, J. C. Sacro-coccygeal sinuses and cysts. Surg. Clin. N. America, 5: 737, 1925.

61. MECHLING, C. C. Congenital proctologic defects in twins. J. A. M. A., 102: 367, 1934.

62. MOISE, T. S. Staphylococcus meningitis secondary to a congenital sacral sinus. Surg., Gynec. & Obst., 42: 394–397, 1926.

63. MORTER, C. W. Excision of pilonidal sinus— partial primary closure. Tr. Am. Proct. Soc., 29: 13, 1928.

64. McKIRDIE, M. Pilonidal sinus. Ann. Surg., 107: 389–399, 1938.

65. NEWELL, R. L. Coccygeal sinus. Brit. J. Surg., 21: 219–228, 1933.

66. OEHLECKER, F. Sacral abscesses by congenital skin displacements. Deutsche Ztschr. f. Chir., 197: 262, 1926.

67. OTTENHEIMER, E. J. Some observations on the treatment of pilonidal sinus. Am. J. Surg., 21: 120, 1933.

68. OTTONELLO, P. Contributo alla conoscenze della syndromi rare da tumori embriogenetici. Riv. di pat. nerv., 41: 512–531, 1933.

69. OWEN, H. R. Pilonidal cyst or sinus with a report of 40 cases. *S. Clin. N. America*, 14: 117–126, 1934.

70. POUTHIOU, LAVIELLE, P. J. The sacrococcygeal infundibulum and congenital paracoccygeal fistulae. *Internat. Clin.*, 4: 77, 1923.

71. RANKIN, F. W. and DONALD, J. M. Dermoid cyst. *S. Clin. N. America*, 12: 913–915, 1932.

72. RIPLEY, W. and THOMPSON, D. C. Pilonidal sinuses as a route of infection in a case of staphyloccus meningitis. *Am. J. Dis. Child.*, 36: 785, 1928.

73. ROGERS, H. Pilonidal sinus. *Surg., Gynec. & Obst.*, 57: 803, 1933.

74. ROGERS, H. and DWIGHT, R. W. Pilonidal sinus—observations on one hundred forty cases treated by cautery excision. *Ann. Surg.*, 107: 400–418, 1938.

75. ROGERS, H. and HALL, M. G. Pilonidal sinus—Surgical treatment and pathologic structure. *Arch. Surg.*, 31: 742–766, 1935.

76. SALEEBY, E. and McCARTHY, P. A. Pilonidal sinus in negro. *Ann. Surg.*, 105: 634–635, 1937.

77. SANDISON, J. C. and BROWN, J. B. Tumors of sacrococcygeal region. *J. M. A. Georgia*, 21: 268–273, 1932.

78. SHARPE, A. M. Pilonidal sinus. *Am. J. Roentgenol.*, 38: 308–307, 1937.

79. SHARPE, W. and N. Neurosurgery—Principles, Diagnosis, and Treatment. P. 762. Philadelphia and London, 1928. J. B. Lippincott & Co.

80. SILVERMAN, I. Pilonidal Sinus and its Treatment. *New York State J. Med.*, 39: 1598–1602, 1939.

81. SMILEY, K. E. Pilonidal sinus. *Am. J. Surg.*, 27: 298, 1935.

82. SMITH, N. D. Pilonidal sinus. *S. Clin. N. America*, 19: 1021–1032, 1939.

83. SMITH, R. M. Roentgen irradiation as adjunct to surgical treatment of pilonidal cyst. *Am. J. Roentgenol.*, 38: 308–311, 1937.

84. STALEY, J. C. Sacrococcygeal dermoids. *Minnesota Med.*, 4: 428–432, 1921.

85. STAMMERS, F. A. Spinal epidural suppuration with special reference to osteomyelitis of the vertebrae. *Brit. J. Surg.*, 26: 336, 1938.

86. STONE, H. B. Pilonidal sinus (coccygeal fistula). *Ann. Surg.*, 79: 410, 1924.

87. STONE, H. B. The origin of pilonidal sinus. *Ann. Surg.*, 94: 317, 1931.

88. STONER, A. P. Significance of sacrococcygeal dermoids in relation to rectal disease. *J. Iowa M. Soc.*, 12: 145, 1922.

89. STREETER. Quoted by Stone.

90. STROBOL, W. G. Pilonidal sinus. *Minnesota Med.*, 22: 292, 1937.

91. SWINTON, N. W. and HODGE, C. C. The treatment of pilonidal sinus. *S. Clin. N. America*, p. 699, 1939.

92. TAIT, LAWSON. *Tr. Cong. Adr. Eng. Sc.*, Dublin, 1877.

93. THOMASON, T. H. Cysts and sinuses of the sacrococcygeal region. *Ann. Surg.*, 99: 585, 1934.

94. TERTILLON, M. *Bull. et mém. Soc. d chirurgie no de Paris*, 8: 54, 1882.

95. TOURNEAUX, F. and HERRMANN, G. Sur la persistance de vestiges médullaires coccygiens pendant toute la période foetale chez l'homme et sur le role de ces vestiges dans la production des tumeurs sacro-coccygiennes cong'enitales. *J. de l'ana. et physiol.*, 23: 498–529, 1887.

96. VON BONNEWITZ, O. R. Post anal dimple: dermoid fistula. *Journal of the American Institute of Homeopathy*, 17: 1924, pp. 325–327.

97. WALKER, A. E. and BUCY, P. C. Congenital dermal sinuses: a source of spinal meningeal infection and subdural abscesses. *Brain*, 57: 401, 1934.

98. WARMAN, W. M. A case of fistula-in-ano with pilonidal sinus. *West Virginia M. J.*, 32: 80, 1936.

99. WARREN, J. C. *Phila. Med. Times*, 3: 747, 1873.

100. WARREN, J. M. Abscess, containing hair on the nates. *Am. J. M. Sc.*, 28: 113, 1854.

101. WEINSTEIN, M. Pilonidal sinus. *Ann. Surg.*, 97: 80, 1933.

102. WEEDER, S. D. Pilonidal cyst, its etiology and treatment. *Ann. Surg.*, 98: 385–393, 1933.

103. WENDELSTADT, H. Dissertation. Bonn, 1885. (Quoted by Stone.)

104. WHARTON, D. J. Pilonidal cyst. *U. S. Nav. M. Bull.*, 30: 350, 1932.

105. WHITE, A. H. Postanal so-called "pilonidal" sinus. *Proc. Roy. Soc. Med.*, 31: 982–984, 1938.

106. ZIEMAN, S. A. Pilonidal cysts. *Surg., Gynec. & Obst.*, 66: 231, 1938.

107. Loc. cit.[21,32,59,92,95,106]
108. Loc. cit.[2,7,10,24,25,29,43,57,57,88,89,103,104]
109. Loc. cit.[8,12,24,29,39,41,44,60,73,81,91]
110. Loc. cit.[8,12,14,28,41,47,69,73,81,90,91,104]
111. Loc. cit.[2,35,39,44,61,63,81,86]
112. Loc. cit.[19,35,37,43,63,90,91,96]
113. Loc. cit.[9,15,55,48,62,65,72,79,85,97]
114. Loc. cit.[15,15,23,27,41,53,90,91,93,104,105]
115. Loc. cit.[2,5,10,12,59,69,80,81,98,106]
116. Loc. cit.[8,28,67,69,73,80,90,91,98,104]
117. Loc. cit.[10,19,60,69,90]

MORTALITY AND MORBIDITY IN SURGERY OF THE THYROID*†

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SOME ten years ago I presented an analysis of 148 operations for goiter performed upon 144 patients. It is my purpose now to make certain observations on the surgical technic, the mortality and the morbidity and to appraise in the light of ten years' additional experience certain concepts in regard to disease of the thyroid gland and its surgical treatment.

Whatever may be the etiological factor or factors in hyperthyroidism, it is apparent that hyperthyroidism is not a single condition but may manifest itself in a variety of clinical pictures and with different pathological entities, as determined by histological examination of the glands removed. The indications for surgical intervention in disease of the thyroid depend upon the clinical manifestations of hyperthyroidism, pressure symptoms and malignancy.

It would seem that the surgical classificaiton set forth in the earlier paper is a practical one and we may speak of hyperthyroidism that occurs in (1) adolescent children, (2) in young individuals—so-called Graves' disease—and (3) the hyperthyroidism of adenoma. It would seem that in the hyperthyroidism of Graves' disease there is a perverted secretion of thyroxin and we have intoxication of the individual by some type of incompletely formed or organized thyroxin, with the major damage to the nervous system. Large doses of thyroid extract or thyroxin when given to an individual will produce the tachycardia, the tremor, the loss of weight, the muscular instability, etc., but will not produce exophthalmos. It is also an interesting fact that the thyroid gland in Graves' disease has less iodine content per unit of gland tissue than either the normal thyroid or the gland in nodular goiter. In Graves' disease the threshold for thyroxin retention in the gland is grossly disturbed; a similar defect does not occur in the toxic adenomatous goiter. Furthermore, the hyperthyroidism of adenoma represents an attack primarily upon the cardiovascular apparatus and this type of hyperthyroidism is seldom associated with eye symptoms.

Another interesting feature of the hyperthyroidism of Graves' disease is that it "ebbs and flows" with periods of remission with comparative well being in spite of a continuing plus metabolism. Uninterrupted thyroidism means eventual degeneration of heart, brain, liver and muscular tissue, and there is a not infrequent group of individuals surviving in society with permanent hyperthyroidism and exhibiting various types of chronic invalidism from organic degeneration.

In so-called "border line" cases time will make the diagnosis positive. If a patient is suspected of being a border line thyroid case, delay will not be dangerous for the patient; and if it is a border line thyroid disease, it will declare itself in no uncertain terms if left alone. Laboratory tests for iodine or blood cholesterol determinations have not proved of much value in these individuals.

The final arbiter of success in thyroid surgery will be based upon the mortality

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and morbidity following operation. A number of factors enter into the consideration of every thyroid patient: (1) the "heart age"—not necessarily the year age; (2) the chronicity of the hyperthyroidism; (3) the weight loss during the hyperthyroidism, and (4) the patient's response to preoperative treatment. In hyperthyroidism autodigestion of tissue takes place with the greatest injury to the liver parenchyma, dehydration is almost a constant finding and proper and adequate surgical management will adopt all measures to aid depleted liver function.

Most of the patients that come to the surgeon have been taking large doses of iodine over long periods of time. We are recovering fortunately from the iodine debauch of the last fifteen years in regard to its application to thyroid disease. Yet it is still surprising to find a great many patients who have had hyperthyroidism for years and who have been intermittently under iodine therapy. These constitute the most refractive type of thyroid disease and are always difficult to bring within operative control, for there seems to be a fixation of the thyroxin mechanism under repeated or prolonged iodization.

It was early apparent that ligation of the superior pole of the thyroid brings about improvement in about 65 per cent of the cases, whereas hemisection is followed by improvement in about 85 per cent. With increasing experience we have paid less and less obeisance to basal metabolic determinations. Personally, I am convinced that there are some individuals with hyperthyroidism that have an apparently normal metabolism as estimated by our present laboratory methods of determination. Furthermore, basal metabolism has no comparative value if and when performed by different laboratories. Habitual use of the same laboratory does tend to give a fair evaluation. We have had patients come with basal metabolic reports of +50, or +60, which without any change in therapy gave a +28 or +30 in our laboratory. It is not an uncommon experience

that under rest in bed, without any medication whatsoever, a high metabolic rate can be substantially reduced and under continuous rest in bed may be brought almost to a normal rate.

If the present concept of thyroxin metabolism be correct, the basal metabolism tells only the velocity of thyroxin manufacture at the time the test is made. However, it is a confirmed observation that postoperative crises occur in patients with low blood iodine. Basal metabolism is the weakest of all criteria for determining when to operate. True, a high basal metabolism indicates a high degree of blood iodine but a low basal metabolism in a hyperthyroid patient means that the danger of surgical intervention is relatively greater. Under hyperthyroidism the patient loses iodine and calcium as exhibited in the weight loss and increased calcium elimination by the urine.

The value of serial basal metabolism tests as a gauge for estimating the ability to withstand surgical intervention is greatly overestimated. The clinical condition of the patient is a much more reliable indication for thyroid resection than is any arithmetical figure of basal metabolism. Of more striking importance as a guide to surgical intervention is the degree of improvement in the patient as exhibited under adequate preoperative treatment. After a hyperthyroid patient by rest in bed, has become relaxed, is eating well, and dehydration has been overcome, with the pulse regular and of less frequency, we permit the patient to get out of bed and to do a little walking. The pulse is taken one-half hour before they are allowed out of bed, taken one-half hour after light activity and at the termination of an hour out of bed. A variation in pulse rate under this light form of activity, of more than ten or fifteen beats, and a persistence of an increase in rate of ten to fifteen beats for a period longer than an hour after the return to bed is considered a contraindication for surgical intervention. However, if the patient recovers the same pulse

rate upon being returned to bed after being up one hour we deem that patient capable of sustaining a thyroid resection.

In the preoperative preparations of all hyperthyroid patients a uniform plan is carried out. Seriatim the procedures are: (1) initial basal metabolic test; (2) a survey of the nasorespiratory apparatus; (3) a competent cardiac and laryngoscopic examination; (4) a complete rest in bed but occasionally allowing toilet privileges; (5) an ice bag, enclosed in woolen container, over heart and thyroid region, alternate hours from 9 A.M. to 6 P.M.; (6) a high caloric diet, with protein at least twice a day; (7) forced fluids by mouth; (8) a daily infusion of 1,000 cc. of normal saline plus 5 per cent dextrose. If dehydration is manifest a second daily infusion of 1,000 cc. of distilled water plus five per cent dextrose is given; (9) sedation, usually in the form of the barbitrates, ½ to 1 gr. of luminal three times a day; (10) daily sodium iodid gr. 7, intravenously, irrespective as to whether the patient is taking iodine by mouth. This procedure vary markedly reduces the preoperative hospital days.

The oxygen content of nitrous oxide is 9 per cent, ethylene 15 per cent and cyclopropane 50, and as goiter patients have an anoxemia, cyclopropane should theoretically be the anesthetic of choice. Cyclopropane, however, induces ventricular fibrillation and its explosive qualities are an ever present danger.

The hyperthyroid patient has a damaged liver and since avertin must be metabolized by the liver we have not been convinced of the wisdom in its choice. It may inhibit an inadequate liver metabolism after operation. However, a greater danger is a preoperative tachycardia as the result of having an anxious, wide-awake patient, waiting in the anesthetizing room and hearing the noise and bustle of an operating room. A preoperative tachycardia will exhaust the cardiac reserve necessary for a successful operation. We employ a partial rectal anesthesia or sedation by the use of paraldehyd in starch water solution in the proportions of 1 cc. of paraldehyd for ten pounds of body weight. This amount is diminished in the thin and emaciated, as well as in the very obese. With the exception of operations for ablation of the thyroid in heart disease, ethylene is almost uniformly employed for inhalation anesthesia.

It is a rather interesting commentary in looking over the series how seldom digitalis or allied drugs were used before operation.

Postoperative hemorrhage is rarely fatal. When bleeding does occur it appears in two forms: (1) hemorrhage under the skin flap; this type is easily recognized and controlled. At its worst it produces only a subcutaneous hematoma. (2) Hemorrhage underneath the muscles of the neck. Here it is not the gross quantity of blood that is lost that is dangerous but the retention of the blood in the traumatized fossa of the thyroid. Hemorrhagic collections in this location very quickly produce tracheal pressure, pressure on the laryngeal nerve and rapidly produce strangulation. Postoperative stridor is a danger sign of the utmost importance and the patient literally shrieks for an opening of the wound to release laryngeal pressure.

In this entire series postoperative hemorrhage was present in only four cases and none required re-operation for hemorrhage. A subcutaneous hematoma occasionally developed which, treated palliatively, was without any grave apprehension upon the part of the surgeon. Occasionally, bleeding would occur from the extremities of the skin incision requiring an additional Michel clip. There is, however, a peculiar complication that may occur following the subtotal resection. It is obvious that the divided muscles, after being united, are rather grossly injured, become edematous, spastic, thickened and unyielding. If these muscles are approximated over the trachea and there ensues a small degree of bleeding from the bed of the removed thyroid gland, continuous and progressive tracheal

pressure is exerted, with a gradual loss in the quality of the voice, and with a marked dyspnea from a relatively small collection of blood placed in a very disadvantageous position. This has occurred about three times in the entire series. This postoperative syndrome makes its appearance shortly after operation and in from three to four hours becomes progressively worse. The surgeon is under the impression he is dealing with a postoperative hemorrhage and may reoperate upon the patient, with further trauma. In addition to blood, a collection of serum in either fossa of the thyroid, held under densely spastic muscles, will produce the same postoperative complication. The symptomatology is so clear that having once observed the condition it is readily recognized and the treatment for it is surprisingly simple without any additional risk to the patient. When a patient, who has had a normal voice and breathing sounds immediately after operation, begins to develop a stridor with dyspnea, the Michel clips or sutures should be removed and the skin flaps elevated and some sterile gauze inserted under the flaps. At the end of a couple of hours the skin flap is elevated and the sutures uniting the muscle are divided and sterile gauze lightly packed into the space that presents itself upon the retraction of the divided muscle ends. From this time on the patient will gradually become better as the fluid collection will seep to the surface. At the end of forty-eight hours practically all of the symptoms due to this particular type of complication will have subsided and the muscles and skin flaps may be resutured with but a slight increase in hospital residence. In this entire series tracheotomy was employed on only two occasions, both for Riedel's struma.

Intrathoracic goiter has certain distinctive and well defined features. It is the end result of an adenoma that has had its origin in the neck, and later descends into the thorax, always carrying with it a blood supply that has been derived from the cervical vessels. The transverse and anteroposterior diameter of some intrathoracic goiters is so great that they cannot be removed intact without enlarging the superior aperture of the chest. We have not found it necessary at any time to divide the manubrium or the sternum to eviscerate an intrathoracic goiter. We have not hesitated to puncture an intrathoracic goiter with the finger and permit the soft, pulpy material to be evacuated through the puncture wound. The immediate result appears to be like a gross hemorrhage but it is only the highly vascularized contents of an encapsulated adenoma; with the collapse of the goiter, the intrathoracic shell, so to speak, can be brought into the neck and resected by more or less accepted forms of technic. It is of great importance in dealing with an intrathoracic goiter that the superior pole be ligated and divided so that the goiter may be eviscerated from above down over the manubrium. This is always possible if the goiter is freed of any attachment at the superior pole. In this way the main and major portion of the blood supply of the adenoma, the inferior thyroid, is brought up with the tumor into the exposed field of the neck.

The most distressing and dangerous complications following thyroid surgery are those that arise from disturbance in the innervation of the intrinsic muscles of the larynx. The larynx subserves two functions: one the respiratory function and the other the voice function. It is the respiratory function that is so vital for a continuation of normal breathing. The recurrent laryngeal nerve has two different groups of conducting fibers: one set supplies the abductor muscles and concerns itself with the amount of air space for respiration; the other conducting fibers supply the adductor muscles which are concerned with the voluntary muscles of the larynx and function in voice production. "About three times as many fibres are concerned in the performance of the

adductor function of the larynx as in the abductor function."

Some doubt has been cast upon the assumption that the superior laryngeal nerve is entirely a sensory nerve. It would seem that this nerve exercises some motor function concerned with voice as exhibited by the hoarseness that follows the continued use of the voice after some thyroid resections. It is an impression of mine that about 10 per cent of the patients with thyroid disease have some preoperative disability of the vocal cords not necessarily exhibited clinically by voice changes. The size and type of goiter apparently are not determinant factors as the impaired cord may not be on the same side as the largest tumor. Contralateral pressure, deviation of the trachea or stretching of the nerves may be the factor at fault. Furthermore, I believe that about 10 per cent of all cases submitted to bilateral thyroid resection have some temporary postoperative vocal cord disability. The majority of these eventually recover. Laryngoscopic examination during operation, or immediately thereafter, would tend to give a higher incidence of voice changes than that which eventually occurs.

It is an interesting fact that in complete ablation of the thyroid in which every effort is made to take out the entire gland there has been less voice disabilities than in the typical standard resections. I do not believe that the laryngeal nerves are cut or divided during the course of the modern operation, but I am quite convinced that subsequent cicatrization or secondary degeneration following trauma incurred at the time of the operation does produce a late postoperative paresis of one and rarely but unfortunately of both cords.

I have had a personal experience in private practice with two cases of bilateral paralyses of the vocal cords. The first occurred fourteen weeks after a bilateral resection for Graves' disease and the second followed an extensive operation for a huge intrathoracic goiter.

There are today two schools of thought regarding the laryngeal nerves in thyroid surgery: one, that in every case the recurrent laryngeal nerves should be exposed, dissected clear and followed to their final termination so that each nerve in turn is visualized during the entire operation. The other school holds to the belief that the less the surgeon sees of the laryngeal nerve the better. It has seemed to me that if artery clamps are always applied to thyroid tissue, well above the level of the branches of the inferior thyroid vessels and the resection is carried out from the midline outward entirely above the posterior capsule, anatomical severance or injury to the nerve does not occur.

The disabilities of voice changes in thyroid surgery are not without hope as time does bring about a remarkable compensation or even alleviation of the symptoms. I have in mind a gentleman who had bilateral disability and under electrical stimulation and time has gained a fair volume of voice and no breathing disability.

Of increasing importance is malignancy of the thyroid. Cancer occurs approximately in 3 per cent of all individuals having thyroid surgery. There are two types of malignancy that arise in the thyroid gland: one has its origin in adenomas and as long as it is encapsulated the prognosis is not hopeless. Carcinomas that arise from bronchial remnants and develop both in front and behind the carotid vessels have a much more dubious prognosis. Carcinomas from adenomas are radiosensitive, and even when incompletely removed an added number of years of life may be reasonably expected when surgery is followed by x-ray therapy.

It is a surprising thing how rare tetany is demonstrable in thyroid surgery. In a more than cursory review with this point in mind I have had in my own practice only one undoubted case of tetany. This patient had as wide a thyroid resection as possible for malignancy and was subsequently treated with x-ray. About three months after the operation she began to have typical tetanic convulsions which

were treated by Collips parathyroid hormone, plus calcium by mouth. In the first year the treatment was adequate because the patient usually had plenty of warning and was able to have her physician give her the required hypodermic injection. At the end of about three years she required no further injections of Collips serum but did complain of mild, transient attacks of laryngeal spasm with dyspnea. Upon giving the patient prostigmine hydrobromide by mouth these symptoms completely disappeared and at the end of about three months of such medication the patient was completely well and in the last year has had no trouble nor required any medication.

TABLE I

A STUDY OF THE MORTALITY FROM JULY, 1923 TO 1939, BASED UPON THE PATHOLOGICAL EXAMINATION

	No. Patients Operated	Mortality Deaths
Graves' disease (incidence)	287 (44%)	12 (4.2%)
Toxic adenomas (incidence)	103 (16%)	3 (3%)
Nontoxic adenomas (nodular, colloid and cystic)(incidence)	237 (36%)	0
Thyroiditis-Riedel's struma	10 (1.5%)	0
Carcinomas (1 sarcoma) (incidence)	15 (2.3%)	3 (20%)
Total series	652	18 (2.7%)

It is also curious that in the widest possible removal of the thyroid—ablation of the thyroid for heart disease—there has been no tetany or tetanic symptoms. It is true that every effort is made to preserve the parathyroids by careful dissection yet when one contemplates the difficulty of identifying the parathyroids and the resulting cicatrization that occurs in the thyroid fossa, it is surprising that we do not see tetany after this type of operation.

An analysis of a series of operations for thyroid disease will reveal certain trends and changes incident to improvement both in the technical procedures and in the experience of the operator. Mortality percentage, important though it be, is not the only criterion of success. What was the final result in those that survived? How complete was the relief? What morbidity ensued and how many patients were incompletely relieved? These questions are all pertinent to the inquiry.

Graves' disease contributed 44 per cent of the material;* toxic adenomas 16 per cent; nontoxic adenomas 36 per cent; thyroiditis, including Riedel's struma, 1.5 per cent, and malignancy 2.3 per cent. (Table 1.) There were 662 operations performed on 626 patients, as follows:

Bilateral subtotal resection	456
Unilateral subtotal resection or lobectomy	126
Local resection	57
Complete resection (ablation)	13
Polar ligation	6
Incision and drainage (for abscess or cellulitis)	4
Total operative procedures	662

From July, 1923 to January 1, 1939, there were 287 patients operated upon for Graves' disease. The average age of the patients was thirty-four years, composed of fifty-six males and 231 females. The average duration of symptoms was 1.5 years, and 226 or approximately 80 per cent had demonstrable eye signs. The average basal metabolic rate was 46 per cent and there were twelve deaths, or 4.2 per cent mortality. (Table II.) An interesting fact emerges if we survey the effect of establishing a goiter clinic. From July, 1923 to 1929, there were seventy-three patients with Graves' disease, with an average duration of symptoms of 2.6 years and a mortality of 8 per cent. From 1929 to 1934 there were 106 patients with symptoms of 1.1 years duration and a mortality of 5.6 per cent. From 1934 to 1939 there were 108 patients with symptoms of one years' duration and no mortality, and in the last 163 operations for Graves' disease there has been no death.

* Diagnosis based upon pathological examination of tissue removed up to December, 1938.

The contrast between Graves' disease and toxic adenomas is marked in many details. Toxic adenomas comprised 16 per cent of the operative material. The average age of this group was forty-four years, as against thirty-four years for the Graves' disease group, and less than 5 per cent had eye signs. Furthermore, the years, 1934 to 1939, in forty-six patients there were three deaths or 6.5 per cent. For the total number of 103 patients the total death rate was 2.9 per cent.

When we analyze nontoxic adenomatous goiter we find that the average age of the patients at the time of surgical intervention —thirty-nine years—lies exactly half way

TABLE II
A STUDY OF GRAVES' DISEASE IN A FIVE-YEAR PERIOD

Operative Period	No. of Cases	Aver. Age, Yrs.	Sex		Aver. Duration Symptoms, Yrs.	Eye Signs	Average B.M.R.	Deaths
			M.	F.				
July 1923 to 1929	73	31	11	62	2 6	63	53+	6 (8%)
1929 to 1934	106	35	19	87	1 1	73	49+	6 (5 6%)
1934 to 1939	108	34	26	82	1	90	39+	0
Total for series	287	34	56	231	1 5	226	46+	12 (4 2%)

TABLE III
A STUDY OF TOXIC ADENOMAS OF THE THYROID IN A FIVE-YEAR PERIOD

Operative Period	No. of Cases	Aver. Age, Yrs.	Sex		Aver. Duration Symptoms, Yrs.	Eye Signs	Average B.M.R.	Deaths
			M.	F.				
July 1923 to 1929	8	42	0	8	12	0	34+	0
1929 to 1934	49	44	1	48	1 7	3	32+	0
1934 to 1939	46	44	6	40	1 3	2	29 + 6	3
Total for series	103	44	7	96	2 3	5	31+	3 (2 9%)

average basal metabolism was 31 for toxic adenomas as contrasted with +46 in the Graves' disease group. (Table III.)

In regard to mortality rate a paradoxical situation arises in our series in that there were less deaths following surgery for toxic adenomas than for Graves' disease. The occurrence of deaths in a series is rather a matter of the "run of affairs." For example, from 1923 to 1934 in fifty-seven patients operated upon for toxic adenomatous goiter there were no deaths, yet in the next four between the age group of Graves' disease thirty-four years—and toxic adenoma— forty-four years. It is reasonable to assume that many of the nontoxic adenomas would change to toxic adenomas within the succeeding five years. The average basal metabolic rate for nontoxic adenoma was +6. There were in all 237 patients operated upon, with no mortality. (Table IV.) In 287 operations for Graves' disease there were thirty-one complications, as follows: wound infections, seven; severe postopera-

tive thyrotoxicosis (crises) six; cardiac decompensation, four; postoperative hemorrhage, three; bronchitis, three; postoperative psychosis, two; atelectasis, two; vocal cord paralysis, unilateral, two; carbuncle of buttocks, one; severe cystitis, one. In 103 operations for toxic adenomas, there were fourteen complications, as

hypodermic injection of ergotamine tartrate (gynergen). Dr. Milton C. Peterson, Chief of the Department of Anesthesia at the Post-Graduate Hospital, states that early in the course of a resection of the thyroid he has given a subcutaneous injection of .25 mg. of ergotamine tartrate. Later, at the beginning of the resection

TABLE IV
A STUDY OF NONTOXIC ADENOMAS AND NODULAR GOITER IN A FIVE-YEAR PERIOD

Operative Period	No. of Cases	Aver. Age, Yrs.	Sex		Aver. Duration Symptoms, Yrs.	Eye Signs	Average B.M.R.	Deaths
			M.	F.				
July 1923 to 1929.............	16	31	3	13	10	3	17+	0
1929 to 1934.................	110	37	11	99	3.2	6	7+	0
1934 to 1939.................	111	32	20	91	3.1	2	4+	0
Total for series....	237	39	34	203	3.6	11	6+	0

TABLE V
A STUDY OF RIEDEL'S STRUMA AND CARCINOMAS OF THE THYROID FROM JULY, 1923 TO 1939

Pathology	No. of Cases	Aver. Age, Yrs.	Sex		Aver. Duration Symptoms, Yrs.	Average B.M.R.	Deaths
			M.	F.			
Riedel's struma (thyroiditis).......	10	38	2	8	2	(114+ to 20−)	0
Carcinoma (1 osteosarcoma).......	15	48	1	14	2.1	....	3

follows: cardiac decompensation, seven; postoperative thyrotoxicosis, three; wound infection, two; diabetes, one; otitis media, one. In 237 operations for nontoxic adenomas, there were fourteen complications, as follows: cardiac compensation, five; bronchitis, three; tracheal compression, one; cerebral embolism (mild) one; otitis media, one; postoperative hemorrhage, one; wound infection, one. In twenty-five operations for carcinoma and Riedel's struma there were four complications as follows: tracheal collapse, two; cellulitis on neck, one; crisis, one.

It has been found that the rapidity of pulse rate during the course of operation can be very markedly influenced by the

of the second lobe, he has given a second dose of .25 mg. in the intravenous normal saline solution. The pulse dropped from 180 to the neighborhood of 100, the blood pressure was sustained and the effect was very prolonged. This is a procedure that is well worth considering in the grave thyroid risks.

It is to be anticipated that nodular goiter will have a tendency for reformation of new adenomas. Such a condition is in no way comparable with the recurrence of hyperthyroidism in Graves' disease. The degree of hyperthyroidism is not proportional to the size or weight of the thyroid that is left after subtotal resection. A very small quantity of active thyroid

tissue left *in situ* may mean the prolongation of hyperthyroidism, or after a period of apparently normal thyroid secretion, may have a secretory reactivation and without enlargement or hypertrophy reinitiate the signs and symptoms of hyperthyroidism so that a portion of thyroid on one or other side of the neck, 2 cm. by 1 cm., has been in some of our cases a cause for reactivation or recurrent hyperthyroidism. It is basically true that the permanence of relief from hyperthyroidism and the prevention of recurrence of symptoms rest primarily on the completeness of the resection.

	No. of Patients Operated	Deaths	Mortality Per Cent
Graves' disease (incidence).............	315	12	3.8
Toxic adenomas (incidence).............	128	3	2.4
Nontoxic adenomas (incidence).............	258	0	
Thyroiditis and Riedel's Struma (incidence)....	10	0	
Total.............	711	15	2.1
Malignancy.............	16	3	18.7
Total.............	727	18	
Mortality including malignancy.............	...	..	2.6

To the previous series seventy-five cases have been added for 1939 and 1940.

In our own series approximately 3 per cent of the cases of Graves' disease had a recurrence of hyperthyroidism and approximately 3 per cent came to us from other clinics, making an overall of recurrent hyperthyroidisms of 6 per cent in the cases of Graves' disease.

I, personally, am convinced that chronic infection of the nose and throat may produce symptoms such as tachycardia and nervousness in a patient who has been sensitized by chronic hyperthyroidism, symptoms closely corresponding to the typical symptomatology of hyperthyroidism. It is our policy to try to prevent the continuation of any nose and throat infection or for that matter any chronic infection in a patient who has been submitted to thyroid surgery.

Approximately 50 per cent of the cases of toxic adenomas have cardiac symptoms and at least half of these have definite organic heart disease. The degree of heart impairment is directly proportional to the chronicity of the hyperthyroidism and some of the most brilliant result in thyroid surgery are obtained in the patients with thyrotoxic heart conditions from toxic adenomas. The operative risk in this group of patients is great; but if a patient with a thyrotoxic heart is able to be on his feet and walk about, he is usually able to survive a thyroid resection after adequate preoperative treatment and rest in bed.

Dividing the operation for thyroid disease into two stages has not been necessary in many patients. In analyzing the causes of death a case might possibly be made out for some of the patients for the two-stage procedure. In only about 5 per cent of all the patients operated upon was a two-stage procedure employed and the two-stage principle has been utilized equally between patients with Graves' disease and patients with toxic adenomas.

CONCLUSIONS

In conclusion it seems that certain concepts result from our analysis: overdosage and continuous administration of iodine preparations are to be discouraged. Iodine does not cure goiter. At best it is of aid in preoperative treatment and the control of symptoms and of great value in crises. Postoperative crises are becoming less and less frequent and have occasioned very little apprehension upon our part in the last few years.

The percentage of cancer of the thyroid is fairly constant and it may be possible

to prevent malignancy by considering every patient with nodular goiter an operative case.

Brilliant results are obtained in the cardiac disabilities from toxic adenomas. In Graves' disease surgery is one phase of the therapy. The patients must be placed under proper medical regimen and controlled for not less than a year after the operation. Basal metabolic determinations are but one sign of hyperthyroidism and overemphasis upon them is to be deprecated. Finally, voice and respiratory difficulties after thyroid surgery are still a pressing problem in the hands even of the expert thyroid surgeon.

THE serious nervous manifestations (in toxic nodular goiter) are most commonly observed in patients who have had evidence of toxicity with remissions over a period of many years, signifying that there was degeneration in the thyroid gland before the manifestations of toxicity and mental aberration began.

From—"Diseases of the Thyroid Gland. Presenting the Experience of More Than Forty Years"—by Arthur E. Hertzler (Paul B. Hoeber, Inc.).

OPERATIVE TECHNIC FOR DIVISION OF RENAL ISTHMUS IN HORSESHOE KIDNEY*

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OPERATIONS for the relief of associated pathologic conditions in the horseshoe kidney have been performed since the opening of this century. Albarran, Israel, Martinow, Kidd, Judd

TABLE 1

SURGICAL TREATMENT OF HORSESHOE KIDNEY. FOUR GROUPS OF CASES

Group 1. Horseshoe kidney not found until postmortem examination, which during life had appeared to be normal and which clinically had presented no urologic symptoms calling for surgical treatment.

Group 11. Horseshoe kidney associated with urologic conditions consisting of: (1) Urinary symptoms, (2) indefinite abdominal pain, (3) gastrointestinal disturbances (most frequently marked constipation), this *triad* constituting the *horseshoe kidney syndrome*, for the relief of which division of the renal isthmus is indicated. The majority of clinical cases fall in this group.

Group 111. Horseshoe kidney with some gross type of associated pathology in one-half of the fused organ, as in calculous pyonephrosis, functionless hydronephrosis, tumor or tuberculosis, in all of which, when unilateral, heminephrectomy is indicated.

Group 1v. Horseshoe kidney with gross associated pathology in both renal pelves, as in bilateral nephrolithiasis or hydronephrosis, in which some type of conservative surgical procedure is indicated in accordance with the functional capacity of each kidney.

and other surgeons operated upon fused kidneys of this type that were found accidentally at operation. But the condition of horseshoe kidney disease was not recognized as an entity until urography was introduced. Since that time, urographic studies have made it possible to diagnose this condition before operation with an accuracy of almost 100 per cent. However, conservative operations for the reconstruction of the anomalous organ did not come into use until rather recently, when Papin, Foley and others began to employ these operations for the relief of symptomatic pain and lack of drainage.

My purpose at this time is to draw attention to the clinical indications for division of the renal isthmus when the diagnosis of horseshoe kidney has been made urographically, and to describe the surgical technic of the operation, with a report of an illustrative case in which I have operated recently for the relief of horseshoe kidney disease, with excellent results.

In Table 1, I have tabulated four groups of cases of horseshoe kidney based upon the type of surgery indicated. These four groups embrace: (1) Cases without symptoms of any kind, discovered accidentally or at autopsy, which clinically had called for no surgical treatment; (2) cases associated with urologic conditions, consisting of urinary symptoms of various kinds, with indefinite abdominal or lumbar pain, and with reflex gastrointestinal disturbances, all more or less chronic or appearing in acute recurrent attacks. These are the cases for which division of the renal isthmus is indicated to restore normal anatomic relations, relieving pressure upon important vessels and nerves and restoring proper renal drainage. They constitute the great majority of clinical cases. (3) Cases presenting some type of gross associated pathology in one-half of the fused organ, for which heminephrectomy is indicated, and (4) cases with gross pathological conditions in both halves of the fused organ, calling for some type of conservative operation based on the degree of functional capacity of each kidney. (Table 1.)

The cases in Group 11 are those in which I am especially interested, since these are the cases that can be restored to normal

function and complete health by simple division of the renal isthmus, followed by a nephropexy of one or occasionally both sides. These cases are the ones most com-

TABLE II
PRINCIPAL INDICATIONS FOR DIVISION OF RENAL ISTHMUS WHEN THE DIAGNOSIS OF HORSESHOE KIDNEY HAS BEEN MADE

Horseshoe kidney disease (horseshoe kidney syndrome)
- A. Urological symptoms of various types
- B. Indefinite renal or abdominal pain
- C. Reflex symptoms manifested in gastrointestinal disorders

TABLE II-A
PRINCIPAL INDICATIONS FOR DIVISION OF RENAL ISTHMUS WHEN THE DIAGNOSIS OF HORSESHOE KIDNEY HAS BEEN MADE

Horseshoe kidney disease (horseshoe kidney syndrome) — A. Urological symptoms and conditions most frequently observed

1. Pyelectasis and caliectasis with evidence of pyelitis and pyelonephritis
2. Moderate degree of hydronephrosis
3. Inwardly rotated renal pelves and calyces that cannot drain, giving evidence of urinary stasis and infection
4. Anterior position of the ureters, situated in front of the renal isthmus, interfering with the dynamism and affecting the emptying time of the renal pelves
5. Repeated crises of urinary disturbances such as infection with dysuria, frequency, hematuria, pyuria, albuminuria and attacks of renal pain and chronic nephritis
6. An intravenous urogram or phthalein test showing that both kidneys still have adequate function to warrant the operation

monly observed clinically, and they constitute what I have elsewhere described as horseshoe kidney disease.

In order to clarify the matter, I have drawn up Table II, in which are shown the principal *indications* for division of the isthmus when the diagnosis of horseshoe kidney has been made. This Table comprises the three major forms of symptoms constituting the triad of the horseshoe kidney syndrome, or as I prefer to call it, the horseshoe kidney disease, which are then graphically subdivided into their details in Tables II-A, II-B and II-C, for more practical use. These tables show: (1) the most common *urinary symptoms* observed, (2) the most frequent types and

sites of *indefinite lumbar and abdominal pain*, and (3) the principal *reflex symptoms* and conditions met with, especially in the *gastrointestinal tract*. This triad or complex

TABLE II-B
PRINCIPAL INDICATIONS FOR DIVISION OF RENAL ISTHMUS WHEN THE DIAGNOSIS OF HORSESHOE-KIDNEY HAS BEEN MADE

Horseshoe kidney disease (horseshoe kidney syndrome) — B. Types of indefinite renal or abdominal pain most frequently observed

1. Pain that has been definitely excluded from other abdominal conditions
2. Pain in epigastric region
3. Pain in umbilical region
4. Pain in right lumbar region
5. Pain in left lumbar region
6. Pain across the back
7. Pain in right or left lower quadrant
8. Pain more marked on bending of the abdomen or stretching of back
9. Pain more obvious upon pressing the renal isthmus at the midline
10. Pain either acute, mild or intermittent according to the degree of inflammation, compression, fixation and position of the anomalous kidney, or according to the degree of pyelitic stasis or any other type of associated pathology that may be present in the horseshoe kidney

TABLE II-C
PRINCIPAL INDICATIONS FOR DIVISION OF RENAL ISTHMUS WHEN THE DIAGNOSIS OF HORSESHOE KIDNEY HAS BEEN MADE

Horseshoe kidney disease (horseshoe kidney syndrome) — C. Reflex symptoms and conditions most frequently observed

1. Disturbances of the gastrointestinal system with the gastroenterorenal syndrome
2. History of chronic constipation
3. History of colitis and diarrhea
4. Reflex pain of indefinite abdominal location
5. Absence of evidence of any other type of gross associated pathological condition in the kidney, which may demand a heminephrectomy
6. Conditions calling for conservative operation on the horseshoe kidney (such as stone or hydronephrosis), in which division of the renal isthmus should always be done to relieve pain and restore renal function

of symptoms lies at the bottom of horseshoe kidney disease. (Tables II, II-A, II-B and II-C.)

ILLUSTRATIVE CASE OF HORSESHOE KIDNEY DISEASE WITH OPERATION FOR DIVISION OF RENAL ISTHMUS AND RIGHT NEPHROPEXY

The urographic examination disclosed the presence of horseshoe kidney with evidence of pyelitis, pyelonephritis and urinary stasis. This condition was relieved by a right kidney

operation consisting of division of the isthmus of the horseshoe kidney, followed by right nephropexy.

FIG. 1. Plain roentgenogram with catheters and cystoscope in position, showing the abnormal position of the right ureteral catheter close to the spinal column and the left ureteral catheter rotated inward, suggesting a fused kidney. Moreover, the shadow of the lower pole of each kidney appears to be running into the midline, suggesting that the fused organ is a horseshoe kidney.

FIG. 2. Bilateral retrograde pyeloureterogram, revealing the presence of a horseshoe kidney. Note the inward rotation of the calyces, the high implantation of the ureters and the lack of drainage which has caused pyelectasis, calyectasis and the *horseshoe kidney syndrome.*

H. M., a woman forty-two years of age, was referred to me for surgical treatment, with a roentgenographic diagnosis of horseshoe kidney, and was admitted to the Murray Hill Hospital on April 4, 1939. She had been suffering with persistent indefinite abdominal pain of many years' duration, which had at times been very acute. Ten years previous to observation appendectomy was carried out without relief. Early in 1939 she had had another attack of abdominal pain, which was then believed to be due to the gallbladder; but x-ray examination of the gastrointestinal tract and gallbladder studies were negative. The patient also had a history of chronic constipation with pain in the epigastric, umbilical and right lumbar regions, frequency of urination day and night, dysuria, urgency, microscopic pyuria and hematuria. These symptoms had been accompanied by intermittent abdominal pain with gastrointestinal disorders and pain across the back off and on for more than twenty years.

Her chief complaints at time of admission were (1) persistent abdominal pain in the epigastrium and about the umbilical region, radiating to the right lumbar region, (2) gastrointestinal disorders and chronic constipation, (3) frequency of urination, dysuria, urgency, albuminuria, microscopic pyuria and hematuria.

The patient was married but had no children. There was no history of pregnancy although she had menstruated since the age of fourteen. Otherwise the gynecological examination was negative. She had always been weak, nervous and anemic. There was a history of chronic constipation from birth, pain across the back off and on which was more severe while standing or bending; gastrointestinal disturbances, abdominal distention and sometimes diarrhea. Appendectomy was done ten years before in an effort to relieve the indefinite abdominal pain in the upper right quadrant as well as nausea, vomiting and rigidity of abdomen.

Physical examination revealed the abdomen to be rigid and contracted, but on percussion one detected the presence of gas. No bowel movement had occurred for four days. Both right and left kidneys were low in position and palpable; the right one was somewhat tender on pressure. After a proper cathartic and daily high colonic irrigations, which allowed the abdomen to become soft, the isthmus of the horseshoe kidney was rather tender and defi-
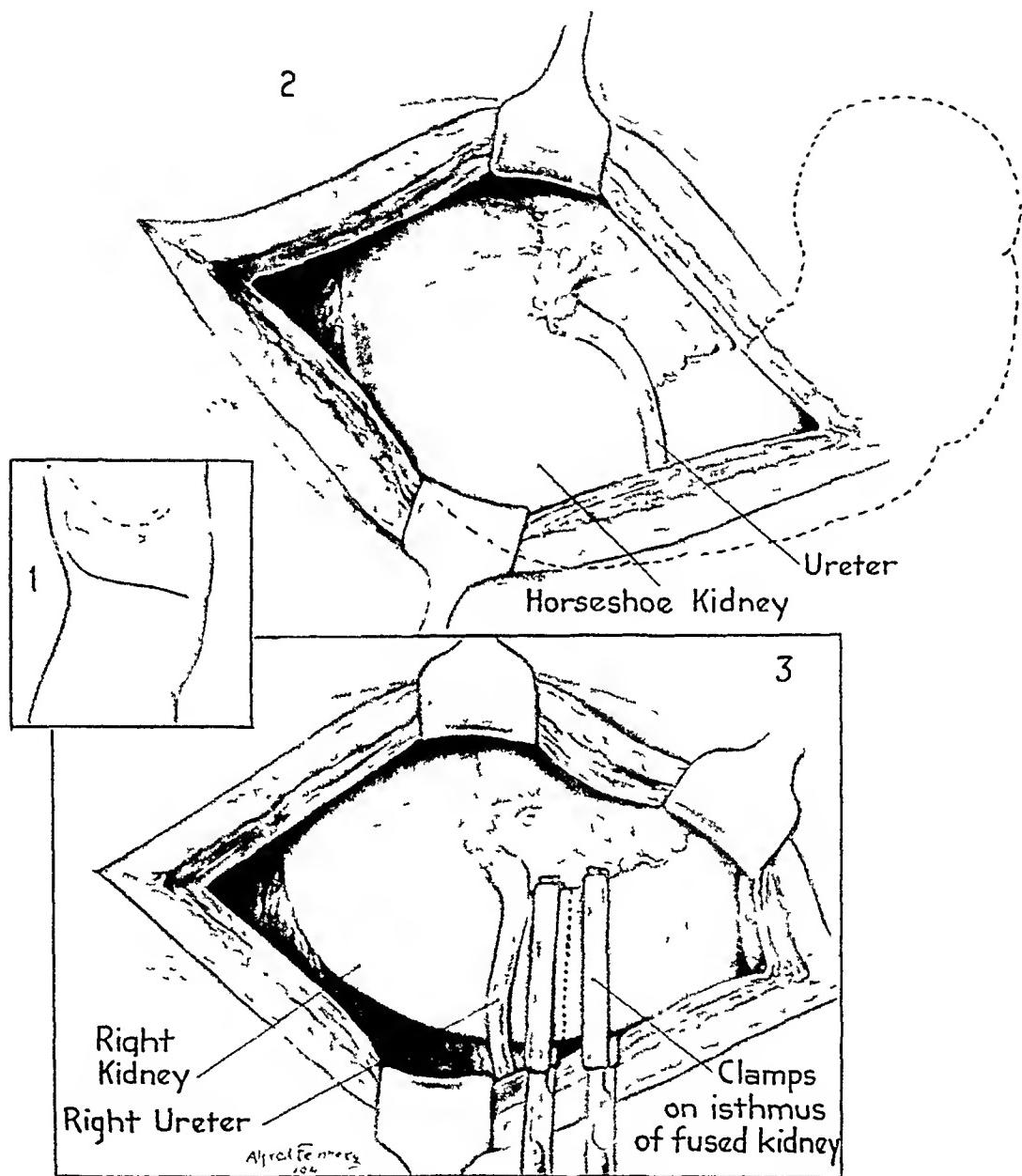
FIG. 3. Operative technic for division of renal isthmus in horseshoe kidney. (1) Drawing of the lumbo-abdominal transverse incision to expose the isthmus of the fused kidney; (2) anatomical exposure of the horseshoe kidney showing the anterior position of the right ureter lying upon the isthmus; (3) the renal isthmus has been mobilized, thoroughly exposed and doubly clamped. The dotted line indicates the line of division of the isthmus between the clamps.
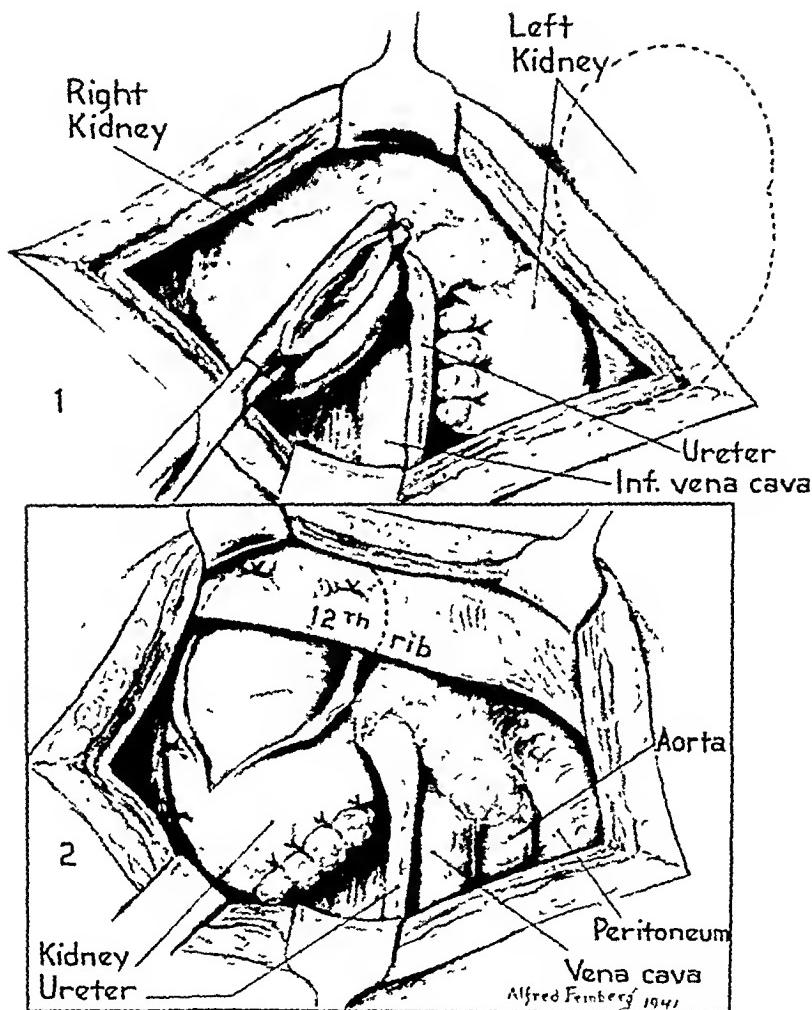
FIG. 4. Operative technic for division of renal isthmus in horseshoe kidney. Final steps in the surgical procedure: (1) The stump of the left portion of the divided isthmus has been sutured over interposed fat to prevent bleeding. This stump of the left kidney is then pushed across the midline under the peritoneum in order to allow it to rotate and occupy its normal position in the left lumbar region. The drawing also shows the rubber clamp holding the right stump of the isthmus in position where it prevents bleeding and facilitates the technical procedures. (2) Surgical exposure of the right kidney and right ureter, revealing the close anatomic relationship to the aorta and vena cava, after the left kidney has been rotated from its position in the midline. The stump of the isthmus of the right kidney has been similarly covered with fatty tissue and sutured by interrupted sutures to prevent hemorrhage and also possible leakage of urine from a sectioned lower calyx. The upper pole of the right kidney has been decapsulated and anchored by nephropexy. The lower pole also has been fixed laterally and posteriorly to the lumbospinal muscles by two separated sutures in order to make the kidney rotate outward and to prevent its contact with the right ureter, thus securing good drainage. The wound is now ready for closure as in an ordinary nephropexy.

nitely palpable in the midline. The urine was hazy and contained pus and blood. Cultures were positive for Bacillus coli; blood pressure

column, giving the impression of horseshoe kidney. The major and minor calyces were dilated, revealing a certain degree of urinary

FIG. 5. Plain roentgenogram with ureteral catheters in position taken three weeks after operation for relief of horseshoe kidney disease. Note that the two catheters are now widely separated from the spinal column and give the impression that both kidneys have rotated and occupy their normal positions in their respective lumbar regions.

FIG. 6. Right retrograde pyeloureterogram taken three weeks after division of the isthmus and right nephropexy, indicating the restoration of normal function and virtually normal anatomical relationship of the excretory apparatus of the organ, which has relieved the horseshoe kidney syndrome.

was 160/100. The patient on admission had a temperature of 100°F. and was quite toxic. The proper urinary antiseptics were ordered, also forced fluids, daily high colonic irrigation and preliminary preparation for urologic and urographic examination the following day.

Cystoscopy, catheterization of the ureters and retrograde bilateral pyelograms disclosed that both kidneys had fairly good function regarding urea and phthalein elimination. A plain film with catheters and instrument in position showed the area of the right kidney to be low and indefinitely outlined. The lower pole appeared to run into the midline about the level of the third lumbar vertebra. The left kidney shadow was also fairly well delineated. The lower pole also appeared extended toward the midline, suggesting a fused kidney placed quite low in position. There was no shadow indicative of stone anywhere in the urinary tract. (Fig. 1.)

The right kidney pelvis was unusual in shape and of real interest. It was rotated inward with the calyces pointing toward the spinal

stasis and pyelitis. The right ureter was well delineated and though placed quite close to the vertebral column, it was within normal limits. The left kidney pelvis revealed a slight degree of hydronephrosis and the pelvis appeared to be twice as large as the one on the opposite side. There was marked dilatation of all the calyces and particularly of the two lower ones, which were rotated inward, disclosing the presence of horseshoe kidney disease. There were also marked pyelectasis, calyectasis and acute pyelitis and pyelonephritis. The outline of the left ureter was well visualized and was within normal limits. However, it appeared that the ureter was inserted high in the upper portion of the renal pelvis and there was some obstruction at the left ureteropelvic junction. (Fig. 2.)

The roentgen diagnosis was (1) fused kidney of the horseshoe type placed across the midline of the spinal column between the third and fourth lumbar vertebrae, (2) horseshoe kidney disease with marked nephroptosis, pyelectasis, calyectasis and acute pyelitis and pyelonephritis.

The patient was treated in a conservative way for about two weeks until the acute symptoms subsided in order to prepare her for

carried further until the isthmus of the horseshoe kidney was clearly exposed. A small blood vessel about the middle portion of the isthmus

FIG. 7. Bilateral retrograde pyeloureterogram of the divided horseshoe kidney after its proper surgical correction, indicating that both pelves have rotated outward and are now occupying a better position, widely apart from the midline, and that both kidneys are now properly draining.

operation. She received a daily intravenous infusion, high colonic irrigations and the proper medications. After all the functional tests were repeated and found approximately normal, and her general condition definitely improved, division of the renal isthmus of the horseshoe kidney was carried out as the only way to cure her, the operation consisting of the separation of the two fused organs, followed by right nephrolysis, ureterolysis and nephropexy, to relieve the acute symptoms and secure better drainage from each kidney.

The operation was carried out on April 21, 1939 under cyclopropane anesthesia. With the patient on her left side in position for a kidney operation, an incision about 10 cm. in length was made from the right costovertebral angle obliquely downward and then straight across to the midline of the body. The muscles and fascia were cut and the fatty capsule of the kidney exposed. Several bleeding points were clamped and ligated. The fatty capsule was opened from behind and the right kidney was readily exposed. (Fig. 3.) The dissection was

was clamped and ligated. Then by blunt dissection the kidney was gradually loosened from its adhesions and separated from its bed, as it was found to be lying on the vena cava, aorta and other retroperitoneal structures of the midline of the abdomen. Then a kidney clamp was passed underneath the isthmus to retract and suspend it, at which time the right half of the horseshoe kidney was freely movable. Two rubber covered clamps were placed in the middle portion of the isthmus, which was then cut across with a knife. There was practically no hemorrhage. The left stump of the cut portion of the isthmus was covered with fat taken from the lumbar wound and tied with four chromic catgut sutures, passed through and through the capsule and kidney parenchyma. As the fat was tied to the raw surface of the stump of the kidney the bleeding was completely controlled. The left half was then pushed with ease to the left side away from the midline. The right half of the horseshoe kidney was sutured with fat in the same

way in order to control bleeding. After this procedure the upper pole of the right kidney was decapsulated and suspended by nephropexy, using two chromic catgut sutures tied to the capsule, and was anchored underneath the eleventh rib by placing the suspension stitch through the intercostal muscles. Another catgut suture was placed in the lower pole and anchored to the posterior sheath of the quadratus lumbaris muscle, in order to relieve the contact of the lower pole of the kidney with the right ureter, thereby eliminating the pressure and obstruction upon the peristaltic contractions of the ureter and allowing better drainage. (Fig. 4.) The operation was completed in the usual manner, the wound being closed by layers: first, interrupted sutures to the fascia; second, interrupted chromic catgut sutures to the muscle; third, interrupted chromic catgut to the fascia and muscle, and finally the skin was closed with interrupted silkworm-gut sutures. A small cigaret drain was left in the upper angle of the wound. A dressing was applied and the patient returned to her room in good condition.

The wound healed by first intention and recovery was uneventful. Before the patient left the hospital on May 9, cystoscopy and catheterization of the ureters and differential functional tests were carried out, and bilateral pyelograms taken, disclosing that the function of each kidney was within normal limits, and that the cultures were negative. The postoperative plain film and bilateral pyelograms (Figs. 5, 6 and 7) revealed that both kidneys had rotated outward to almost their normal position after division of the renal isthmus and the right nephropexy, and that the calyces, right renal pelvis and right ureter were normal in size and almost normal in position. The small degree of hydronephrosis in the kidney of the opposite side was also notably improved and caused no symptoms. Thus it was demonstrated that the conservative operation for the reconstruction of the anomalous organ, consisting of the retroperitoneal exposure and division of the renal isthmus, followed by nephropexy had relieved symptoms and restored normal function.

OPERATIVE TECHNIC FOR DIVISION OF ISTHMUS IN HORSESHOE KIDNEY

In the surgical management of division of the renal isthmus for horseshoe kidney,

the operation should be performed extraperitoneally, exposing the kidney and renal isthmus by a transverse lumbo-abdominal incision, cutting the skin, fascia and plane of muscles, and opening the fatty capsule from behind. The peritoneum should be well retracted in order to expose the isthmus clearly, so that anomalous vessels of the isthmus can be clamped and ligated. Complete nephrolysis and ureterolysis are necessary in order to mobilize the organ. The isthmus of the fused kidney can then be lifted up and two large rubber clamps applied at its middle portion. Directly underneath the isthmus can be seen the aorta and vena cava. The renal isthmus is then divided with the knife between the two clamps, and mattress sutures are applied to its raw surfaces over fatty tissue interposed to prevent hemorrhage. This procedure will facilitate the pushing of the stump of the isthmus of the opposite kidney across the midline so that it will rotate outward to occupy its proper position on the other side of the spinal column, with assurance that there will be no bleeding, and that better drainage will be secured by its new anatomic position. The sectioned surface of the other half of the renal isthmus, corresponding to the side of the operation, is likewise covered with fatty tissue and closed with interrupted or mattress sutures to stop bleeding and also to prevent leakage of urine from the lower calyx that may have extended into the renal parenchyma of the isthmus.

Inasmuch as the operated side of the horseshoe kidney has been liberated and separated from its attachment to the isthmus and other anatomic structures, the kidney of this side is now maintained in position only by its pedicle; therefore, a new position for this half must be secured. In order to rotate the kidney upward and outward, a fixation of the organ is accomplished by a nephropexy. This conservative nephropexy for the suspension and fixation of the half of the fused kidney on the operated side consists of decapsulat-

ing the upper pole of the kidney and fixing it with chromic catgut by the capsule to the twelfth or eleventh rib, just as in any nephropexy. However, it is important also to fix the lower pole of this kidney to the lumbospinal muscles by two chromic catgut sutures (Fig. 4) in order to rotate the kidney outward and prevent it from inflicting chronic insult upon the physiologic peristaltic contractions of the ureter.

The operation can be finished in the same manner as after an ordinary nephropexy, closing the wound with or without drainage.

TABLE III

MAIN POINTS IN THE OPERATIVE TECHNIC OF DIVISION OF RENAL ISTHMUS IN HORSESHOE KIDNEY

1. A transverse lumboabdominal incision, permitting a good anatomic exposure of the renal isthmus.
2. Extraperitoneal approach to the kidney and isthmus.
3. Mobilization of the kidney and isthmus by complete nephrolysis and ureterolysis.
4. Clamping and ligation of accessory blood vessels of the renal isthmus.
5. Double clamping of the isthmus before dividing the renal parenchyma.
6. Closure of raw surfaces of the sectioned renal isthmus by mattress sutures over interposed fat to prevent hemorrhage.
7. Carrying out of a nephropexy with decapsulation of the upper pole and fixation also of the lower pole to the lateral lumbospinal muscles, in order to place the kidney that has been operated upon in a rotated position for the purpose of securing adequate drainage.
8. Closure of the wound as in an ordinary nephropexy with or without drainage.
9. Cystoscopy and bilateral retrograde pyelograms repeated two or three weeks after this unilateral operation to verify the surgical results.
10. Performance of nephropexy on the kidney of the opposite side, if this should be indicated in the check-up pyelograms, in order to relieve pain and secure good drainage from that kidney.
11. This conservative operation of division of renal isthmus and nephropexy is carried out not only to relieve symptoms but also to correct the malformation of the anomalous organ and secure adequate drainage from each of the two kidneys.

After a complete healing of the wound has been obtained by the second or third week following division of the renal isthmus, the patient should be cystoscoped and bilateral retrograde pyelograms repeated in order to verify the surgical results. If pyelographic studies reveal poor function of the kidney of the opposite side and also marked nephroptosis, nephropexy should be carried out in that kidney also, not only to relieve symptoms but also to complete the correction of the malformation of the anomalous organ and secure adequate drainage from both kidneys. (Table III.)

SUMMARY AND CONCLUSIONS

1. In the surgical treatment of horseshoe kidney, four main groups of cases must be considered, which are described in Table I.

2. The triad of symptoms that constitute the horseshoe kidney syndrome or horseshoe kidney disease is stressed and is graphically illustrated in Tables II, II-A, II-B and II-C.

3. The indications for division of the renal isthmus in horseshoe kidney are also discussed in the accompanying Tables II-A, II-B and II-C.

4. The operative technic employed, consisting of nephrolysis, ureterolysis, and division of the renal isthmus, followed by nephropexy, is described.

5. The excellent surgical results obtained indicate the value and feasibility of this conservative procedure.

6. The most important points in the technic of this operation for division of the renal isthmus in horseshoe kidney, have been summarized in Table III at the end of this paper.

REFERENCES

1. GUTIERREZ, R. The Clinical Management of Horseshoe Kidney. New York, 1934. Paul B. Hoeber, Inc.
2. GUTIERREZ, R. Horseshoe kidney, in discussion, J. Urol., 27: 85–88, 1932; 32: 655–657, 1934.
3. GUTIERREZ, R. The value of indwelling ureteral catheters in urinary surgery. Surg., Gynec. & Obst., 50: 441–454, 1930.
4. GUTIERREZ, R. The role of anomalies of the kidney and ureter in the causation of surgical conditions. J. A. M. A., 106: 183–189, 1936.
5. GUTIERREZ, R. Anomalies of the kidney, hydronephrosis, movable kidney, injuries of the kidney. In: Cabot's Modern Urology. 3d. ed., vol. 2, chap. 11, pp. 374–509. Philadelphia, 1936. Lea & Febiger.
6. FOLEY, F. E. B. The surgical correction of horseshoe kidney. J. A. M. A., 115: 1945–1951, 1940.
7. PAPIN, EDMOND. Foreword from Gutierrez, Robert. The Clinical Management of Horseshoe Kidney. New York, 1934. Paul B. Hoeber, Inc.

THYROIDECTOMY*

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THE mortality rate for thyroidectomy in many of the leading clinics in this country is less than 1 per cent. This is remarkably low and speaks highly of the quality work done. One should realize that this does not represent the mass of surgeons throughout the land whose statistics are difficult to obtain. It goes without saying that the mortality is much higher and in some instances alarmingly so. My own mortality rate has been gradually lowered. The last one hundred cases have been done without any mortality, and only one death occurred in the previous one hundred cases. My excuse, therefore, in writing this paper is the hope that by describing a simple technic and emphasizing some points it may be helpful in lowering mortality for others.

In no other field of surgery is thorough knowledge of anatomy and pathology so essential. The surgeon should know where the parathyroids are located normally as well as the location of the recurrent nerve. Every surgeon can learn anatomy and I, therefore, urge him to do so before doing a thyroidectomy. (Figs. 1 to 5.)

Pathological conditions of the goiter vary greatly in different parts of the country due to variation in iodine content of the soil and water and to other factors. In this locale we seldom see a "pure" type. Practically always they are of the mixed variety. In the one microscopic section one may see normal alveoli, excessive colloid areas and even hyperplastic areas.

We believe that iodine benefits almost all patients, also Lugol's solution, 15 m. three times a day and sufficient pheno-barbital for complete rest. At least two weeks' treatment in bed is insisted upon prior to any surgery.

The question of multiple operative stages is much debated. I believe that the age of the patient and the duration of the symptoms are of the utmost importance in making this decision. Many patients stand lobectomy who would die with a complete operation. It prevents collapse of the trachea, minimizes the postoperative tracheitis and prevents the incidence of severe reaction. I believe, too, that ligation operations should be done in severe cases. It is a very minor operation and gives excellent results as evidenced by increased weight, reduction of general nervousness and toxic symptoms. I also believe that this procedure reduces the mortality.

OPERATIVE PROCEDURE

Anesthesia. The choice of anesthesia is more important than is usually considered. I do practically all operations, except on children, under local anesthesia. It definitely minimizes the operation, ensures delicate handling of the tissues and prevents many of the postoperative complications such as tracheitis, bronchitis, shock and general reaction. Many of the large clinics use intratracheal anesthesia. The presence of such a foreign body in the trachea over the period of operation definitely increases tracheitis. I cannot understand why more surgeons do not adopt local anesthesia.

To administer the anesthetic a wheal is raised with a small needle and then infiltration under the skin along a line encircling the operating field. (Fig. 7.) It is usually unnecessary to use intradermal infiltration. The needle is next inserted deeply through the fascia every half inch along the posterior margin of the sternomastoid muscle to block the branches of the cervical plexus

including the postauricular, occipital, transverse colic, acromial and clavicular branches. (Fig. 6.) Great care should be

incision to pull downward, and if it is too low it will ultimately cross the upper part of the sternum and be too conspicuous.

ANATOMY OF THE THYROID
POSTERIOR VIEW

Parathyroids

Inferior Thyroid Artery

Recurrent Laryngeal Nerves

FIG. 1.

Common Carotid Artery

Superior Thyroid Vessels

Inferior Jugular Vein

Thyroid

Middle Thyroid Vein

Clavicle

Inf. Thyroid Art. Piercing fascia

Inferior Thyroid Veins

Substernal Lobe

Thyroid Ima Veins

Innominate Vein

POINTS OF LIGATION
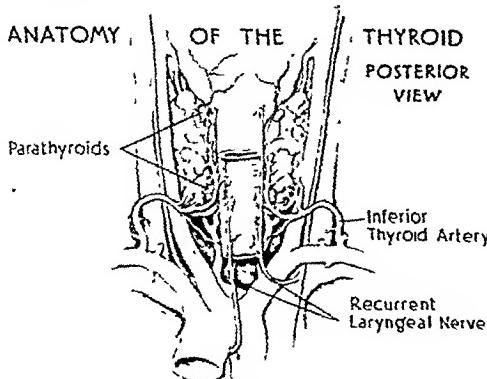
FIG. 2.

FIGS. 1 AND 2. Anatomical studies; self-explanatory.
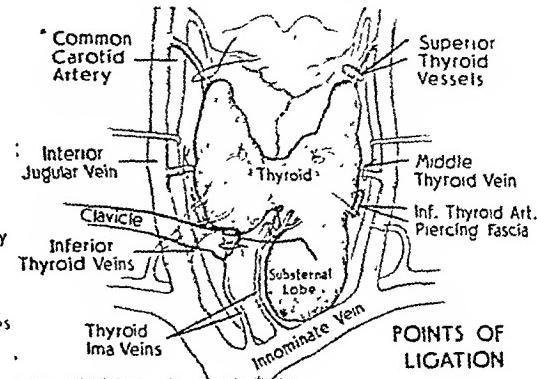
taken to draw back on the syringe each time before injection as occasionally a vein may be entered. Following infiltration through the fascia, the muscles immediately in front of the sternomastoid are injected to block off the descendens hypoglossi. The last step is injection into the superior pole. Usually about 100 cc. of 1 per cent novocain are used with three drops of adrenalin

In the average case the incision need not be too long and a short scar gives better cosmetic result. However, when the thyroid gland is very large, I do not hesitate to enlarge the incision, carrying it upward toward the ear along the sternomastoid as this helps materially in exposing the upper pole of a large goiter. The incision is carried down through the skin, superficial

LATERAL DISSECTION COMPLETED

Middle Thyroid Vein

Capsule

Recurrent Laryngeal N.

Parathyroids

FIG. 3.

Middle Thyroid Vein

Jugular Vein

TRANSVERSE SECTION

FIG. 4.
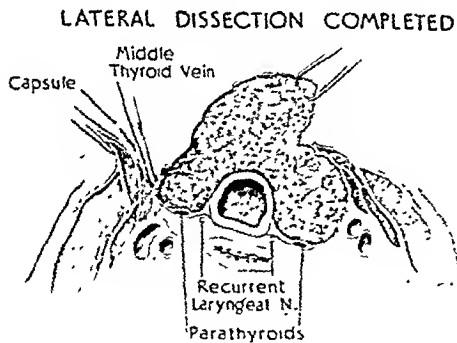
FIGS. 3 AND 4. Anatomical studies; self-explanatory.
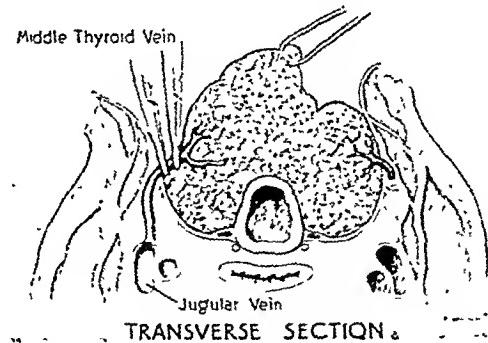
added to each ounce. Some authorities claim that the use of adrenalin precipitates a postoperative storm. I have found no such immediate or late reaction in any of my cases. After the gland is exposed, more solution is injected into the upper pole to block off the sympathetic fibers which accompany the superior thyroid artery.

Incision. The incision (Fig. 8) should be made about one inch above the sternal notch since there is a tendency for the

fat and platysma but not through the fascia. Gauze is then used to assist in stripping the flap upward, using sharp dissection where necessary. The lower edge of the incision is dissected downward in the same manner. This allows better skin approximation and better exposure. The fascia is not cut in a transverse plane. The fascia is incised in the midline with a scalpel and cut with a scissors in a vertical direction from the thyroid cartilage to the

episternal notch, avoiding the anterior jugular vein. The sternohyoid muscles are split vertically in the midline, exposing

CERVICAL PLEXUS

POINTS FOR DEEP NERVE BLOCK

FIGS. 5 AND 6. Anatomical studies; self-explanatory.

the gland with the two thin sternothyroid muscles covering the lobes on either side. (Fig. 9.) The sternothyroids are stripped off carefully and retracted laterally to expose the lateral edges of the lobe.

Steps in Resection. The steps from this point may vary greatly in the hands of different surgeons. Each surgeon of repute has worked out details of resection to his own liking. A carefully planned operation needs to be varied only rarely and greatly facilitates the speed and smoothness of any operative procedure. Our technic is as follows:

Step 1. The upper pole is injected with novocain to anesthetize the sympathetics along the vessels. If this is not done, the patient may complain of discomfort during the operation. Dissection is begun in the

groove between the upper pole of the gland and the thyroid cartilage to release the medial side of the pole. (Fig. 10.)

SUPERFICIAL · BLOCK
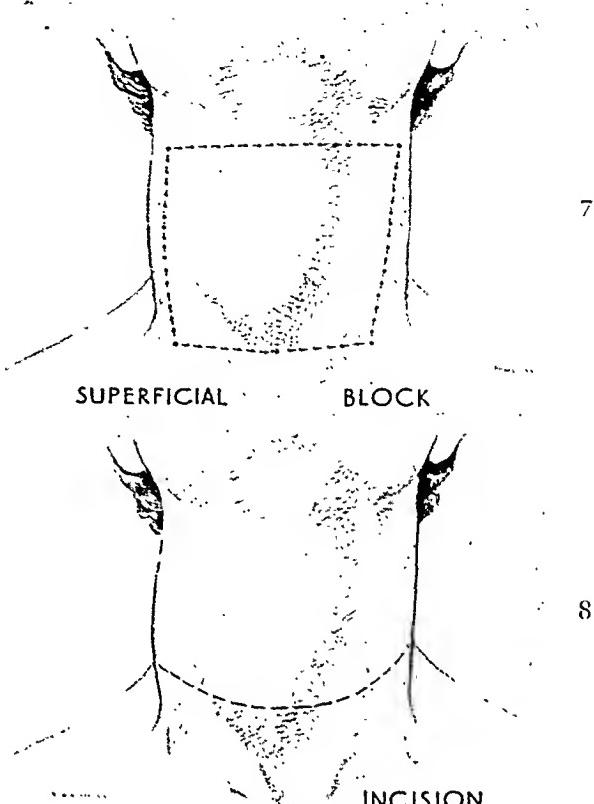
INCISION

FIGS. 7 AND 8. Superficial block and line of incision. In Figure 7 a circular area is infiltrated along the line indicated.

Step 2. The lateral aspect of the gland is retracted by a Percy forceps and the capsule stripped backward. The middle thyroid vein is encountered at this point, and is doubly clamped, cut and tied. (Fig. 11.) The vein enters the internal jugular vein directly and if it is allowed to retract before ligation, undesirable bleeding may occur. It is difficult to follow the proper line of capsule if this vein is not first secured. Gauze dissection is used to strip the capsule upward and posteriorly until the lateral aspect of the superior pole is cleared. (Fig. 12.)

Step 3. The upper pole is exposed by retraction and gently pulled downward, using Percy forceps. (Fig. 13.) If the thyroid gland is unusually large and extends upward, the sternohyoids may be divided. This procedure is rarely necessary but it does give good exposure in difficult

Ross—Thyroidectomy

40

cases. A blunt aneurysm needle is used to thread No. 1 plain catgut under the pole, passing the needle from within outward to

posteriorly some distance from the pole. The medial branch enters the thyroid near the trachea about half way up. It is

MIDDLE THYROID
VEIN SECURED

Middle
Thyroid Vein

DISSECTION
IN LARYNGEAL
THYROID GROOVE

Capsule

CAPSULE
DISSECTED OFF
LATERAL ASPECT
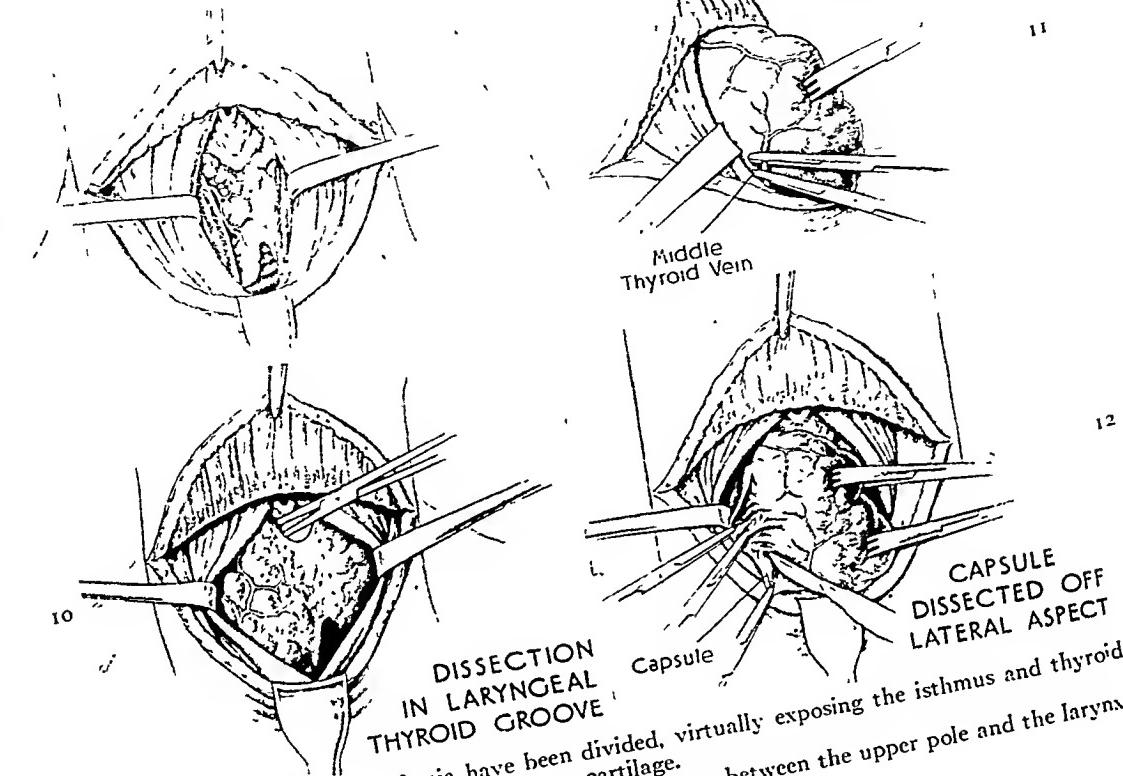
FIG. 9. Thyrohyoids and fascia have been divided, virtually exposing the isthmus and thyroid cartilage.
FIG. 10. Dissection is begun by dissecting in the groove between the upper pole and the larynx.
FIG. 11. Lateral side dissected securing the middle thyroid vein.
FIG. 12. Shows dissection of the capsule.

prevent picking up the superior laryngeal nerve. (Fig. 14.) This procedure is much simpler than using curved forceps and is accomplished with less trauma. The pole is doubly tied and divided, leaving enough tissue distal to the ligatures to ensure their safety.

Step 4. Dissection is carried around the lower pole and the inferior thyroid vessels are clamped close to the gland. It may be noted that the trunk of the main inferior thyroid artery is rarely seen. It emerges through the fascia behind the lower pole and almost immediately divides into three or more branches. One of these branches may have been encountered during dissection of the lower part of the lateral aspect. Another large branch enters the gland

very necessary to remember the location of these branches and to ligate them before they can retract. Grasping for them may cause injury to the recurrent nerves and parathyroids.

Step 5. The isthmus is now divided. Sometimes this procedure is facilitated by undermining with a curved Kelly forceps. (Fig. 14.) Usually, however, the isthmus is divided in small sections by doubly clamping and cutting. When the trachea is reached the dissection is continued laterally; care is taken not to strip the trachea too clean. Usually a layer of fascia is left over it. The lateral aspect of the trachea is freed.

Step 6. The whole lobe is now lifted up to decide how much tissue should be

allowed to remain. A small portion is usually left clinging to the posterior capsule and to the groove between the trachea

few cases some thyroid tablets are necessary postoperatively, but these supply all necessary thyroid secretion to the body.
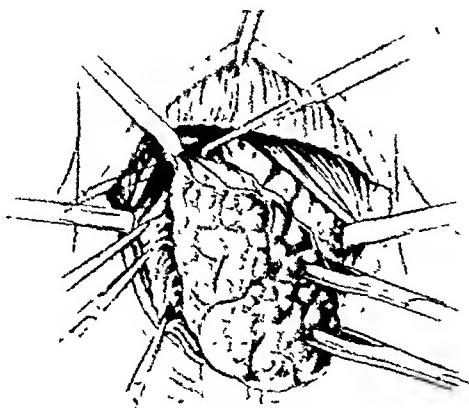
FIG. 13. An aneurysm needle carrying a ligature is passed under the upper pole.
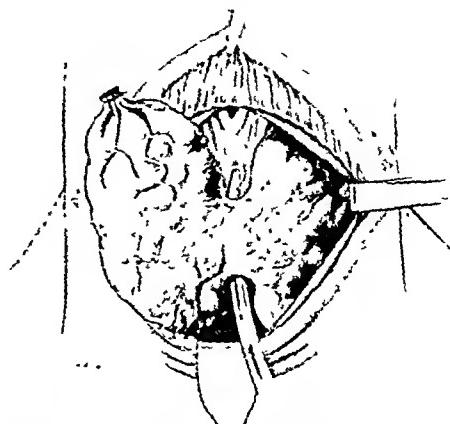
FIG. 14. After freeing the lower pole the isthmus is divided.

and esophagus. (Fig. 15.) The portion between the trachea and esophagus cover the recurrent laryngeal nerve and protects it. The amount of gland to be left is still a matter of surgical judgment. I believe that a small, relatively healthy portion

Careful follow-up with repeated basal metabolism tests is advisable, and I am often agreeably surprised to see the test very satisfactory when a very low metabolic rate was anticipated.

After packing the area gently the isthmus is carefully dissected off the trachea

DISSECTION OF BOTH LOBES COMPLETED

SMALL PORTIONS OF GLAND REMAINING
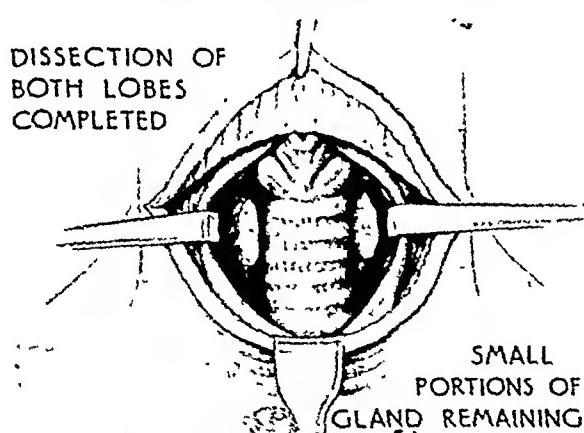
FIG. 15. Both lobes removed leaving a small portion of each.

FIG. 16. Illustrates a new method of drainage. Forceps passes through the sternothyroid muscle and is carried laterally, superficial to it (along the dotted line) and through a thinned-out portion of the sternomastoid muscle. The right side of the illustration shows the tube in position.

of the gland is rarely found. In most cases practically all of the gland tissue is affected. If diseased tissue is allowed to remain, it may continue growing and cause all the symptoms to recur. In spite of great care there will remain a small layer of gland tissue over the recurrent laryngeal nerve area and a small portion over the trachea. For ten years I have done almost complete thyroidectomies and have had no untoward effects. It is true that in a

toward the other side, clearing not only the anterior aspect but a considerable portion of the lateral aspect. Resection of the left lobe is then carried out by the same procedure as used on the right.

Step 7. After making certain that hemostasis is satisfactory the next step is

to suture the layers of muscle and fascia and to establish drainage. I believe that adequate drainage is necessary for twenty-

lateral ends of the wound. (Figs. 16 and 19.) The tube makes its appearance behind the lateral to the sternomastoid
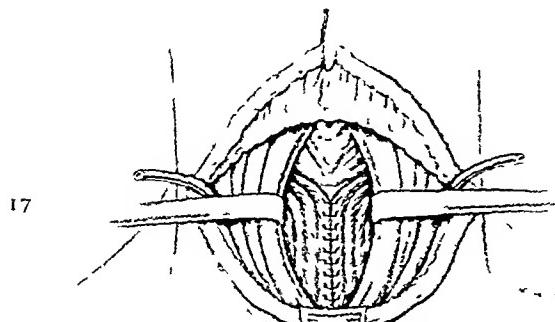
STERNO THYROID MUSCLES SUTURED ACROSS TRACHEA AS A SEPARATE LAYER

GLAND LOOSENED FROM ABOVE
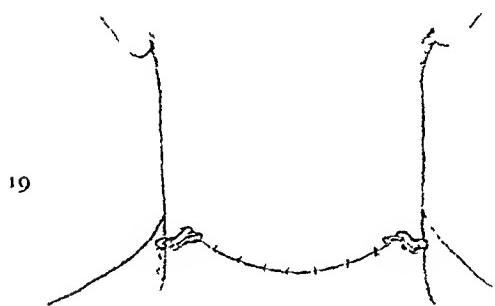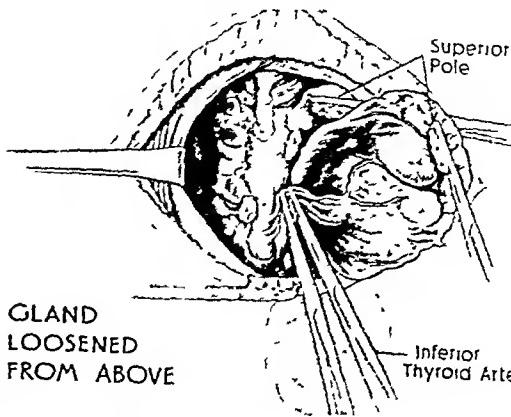
OPERATION COMPLETE

GLAND READY TO DELIVER

FIG. 17. The sternothyroids are sutured as a separate layer over the trachea, protecting it and preventing adhesions to the skin. Sternohyoids are next sutured.
FIG. 18. Skin is closed with skin clips and a few fine dermal sutures. Drainage tubes are shown.
FIG. 19. A substernal goiter is illustrated showing the dissection from above downward, dividing all the attachments shown in Figure 2.
FIG. 20 Substernal goiter with all attachments divided and ready for delivery.

four hours postoperatively. I am aware that certain authorities do not consider drainage necessary. It is assuming the impossible to state that a wide dissection should always be free from some collection of serum. The trachea is very sensitive to changes in pressure and if clots occur they may cause swelling in the neck and collapse of the trachea. For drainage I use a soft gum-elastic tube of small size and have had no harmful effects from its use. In the past, drainage has been established through the midline. Because of this, adhesions to the trachea often developed and caused a pulling in of the skin and scar whenever the patient swallowed. I now establish drainage on each side, bringing the tube out at the

muscle. The procedure is fraught with some danger of injury to the internal jugular vein. The following technic protects the vein: The edges of the sternothyroid muscle are held up under slight tension, using a Percy forceps. A Kelly forceps transfixes the sternothyroid muscle and is carried backward and outward in the plane between this muscle and the sternomastoid muscle and is pushed through the fascia. The tube is then pulled through. The drain for the opposite side is inserted in a similar manner.

Step 8.   In the next step the thin layers of sternothyroid muscles are brought across the trachea and sutured together in this position. (Fig. 17.) This is done to protect
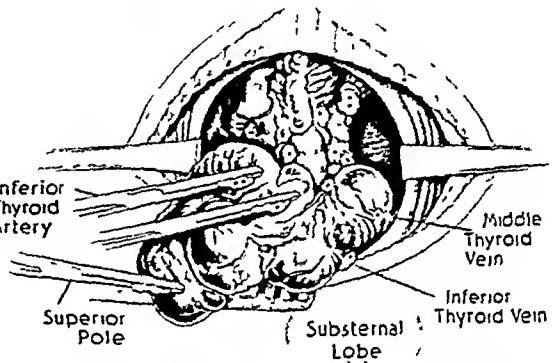
the trachea and prevent postoperative adhesions. The sternohyoid muscles and fascia are then sutured as one layer, using a continuous stitch. The skin, superficial fascia and platysma are brought together with large clips and to secure accurate approximation a few dermal sutures are inserted between the clips. The drainage tubes are brought out the lateral corners of the wound. (Fig. 19.)

SUBSTERNAL GOITER

If the attachments of the gland are well in mind and the gland is divided from above downward, resection of a substernal goiter is quite simple. The attachments may be enumerated as follows (Figs. 2 and 18): (1) the superior pole, (2) the isthmus, (3) the lateral aspect of the trachea, (4) the capsule of gland posteriorly and laterally, (5) the middle thyroid vein, (6) the branches of the inferior thyroid artery entering the gland on the posterior surface, (7) the fascia over the lower pole anteriorly in the neck and (8) the inferior thyroid veins. If dissection is carried out in the order given from above downward, the intrathoracic portion usually can be delivered without difficulty. (Fig. 20.) In rare instances the intrathoracic portion is very large and cannot be delivered. In this case it may be necessary to divide the gland into several portions and deliver it in sections. This procedure can be carried out safely since the blood supply has been cut off previously. This procedure is much preferable to division of the sternum which, in my opinion, should never be done in these cases.

TWO-STAGE OPERATION

The question arises as to which cases should be subjected to a two-stage operation. It is here that excellent surgical judgment is so valuable. There are no definite rules or tests to evaluate properly a patient's ability to stand surgery. In cases of old, long-standing goiter with cardiac decompensation, the operation should be performed in two stages or even three or four stages. In borderline cases it is more difficult to decide. The best criterion is the age of the patient. If the patient is past fifty years of age, the danger of the operation is magnified. I prefer a two-stage operation and a low mortality to a one-stage operation and a high mortality. I do not hesitate to do ligations as a preliminary procedure and am convinced of their value. Preoperative preparation of these patients is important. Prolonged rest in bed with phenobarbital gr. 1½ three times a day, and Lugol's solution is essential. Hospitalization for a few days preoperatively is advisable in all cases.

Edema of the legs does not always mean cardiac decompensation and may be cleared up in many cases by blood transfusion. Adherence to the above principles has enabled me to do the last one hundred cases without a death.

RECURRENT GOITERS

Cases of recurrence of the enlargement of the thyroid gland present a most serious problem since the gland is adherent everywhere and there are no natural planes of dissection. The only advice offered is to stay close to the gland and dissect slowly and carefully, as otherwise the parathyroids or the nerves may be damaged.

SUMMARY

1. Low mortality may be obtained by (a) careful selection of patients and valuation of their ability to tolerate operation, (b) careful and adequate preparation of the patient, (c) a simple and well planned operative technic, emphasizing the delicate handling of tissue and hemostasis, (d) use of local anesthesia is urged and the technic is described and (e) multiple operations are used in bad risks and definitely saves many lives.

2. A radical operation is carried out as a routine, lowering the incidence of recurrence.

3. My operative technic is described, showing a new method of closure and drainage.

ADRENAL APOPLEXY*

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DETROIT, MICHIGAN

ADRENAL apoplexy has come to hold an important position in the differential diagnosis of the acute condition of the abdomen in both the child and adult. In reviewing the cases which have occurred in Harper hospital, of which there were two in adults, it was thought timely to present these cases and discuss the disease and its course in the adult. Lavenson, in 1906, published an exhaustive review of the entire subject of acute adrenal insufficiency. From 1906 to 1928, Pearl and Brunn found twenty cases of acute bilateral suprarenal hemorrhage in the adult recorded in the literature. Since that time there have been twenty-two cases reported and these are listed in the following chart.

tal on Dr. Merritt's service October 26, 1932. He had a temperature of 96.4°F., pulse 96, respirations 24, and was drowsy, listless, irritable, and hiccoughing. Three days before admission he had fallen across a railroad track, injuring his abdomen He remained at home and his condition became worse with nausea, vomiting, pain across abdomen and gross hematuria for two days. He had a history of chronic renal tuberculosis. On examination the abdomen was found to be tender in the epigastrium, mildly distended, free of masses and the liver slightly enlarged. Blood pressure was 120/90. The blood count was normal. The urine was found to contain tubercule bacilli and red and white blood cells. The course was rapidly downhill and the patient expired on the fourth hospital day. Autopsy examination revealed a

Author	Date	Age	Sex	Type	Etiology	Operation	Termination
Goldzieher	1929		Female	Bilateral	Thrombosis	Yes	Death
Taylor	1930	54	Female	Bilateral		Yes	Death
Antonini	1931				Trauma	No	Death
Seligman	1932	31	Male	Right	Trauma	No	Death
Seligman	1932	42	Male	Bilateral	Trauma	No	Death
Seligman	1932	51	Male	Right	Trauma	Yes	Death
Seligman	1932	43	Male	Bilateral	Metastasis	No	Death
Seligman	1932	42	Female	Unilateral	Uremia	No	Death
Seligman	1932	27	Male	Left	Infection	No	Death
Seligman	1932	22	Male	Bilateral	Embolism	Yes	Death
Damon	1932				Convulsion	No	Death
Ikhteyman	1932						Death
Areher	1933			Bilateral			Death
Chandler	1934	55	Male	Bilateral	Trauma	No	Death
Finnegan	1935	35	Female	Bilateral		No	Death
Barsoum	1936	30	Male	Bilateral		Yes	Death
Hall and Hemken	1936	33	Male	Bilateral	Infection	No	Death
Hall and Hemken	1936	40	Male	Bilateral	Infection	Yes	Death
Hall and Hemken	1936	18	Female	Bilateral	Pregnancy	No	Death
Hall and Hemken	1936	63	Male	Bilateral	Leukemia	No	Death
Hall and Hemken	1936	76	Male	Bilateral	Carcinoma	No	Death
Altschule	1939	72	Male	Bilateral	Thrombophlebitis	Yes	Death

OUR CASE REPORTS

Case 1. Mr. F. B., No. 84685, white, age fifty-five years, was admitted to Harper hospi-

tuberculous pyelitis with almost complete destruction of the kidney cortex, multiple miliary abscesses of the left lung, cavernous hemangioma of the liver and a massive hemor-

rhage into the right adrenal with complete neerosis of the adrenal eortex.

CASE II. Mr. C. H., No. 192171, white, age forty years, was admitted to Harper hospital on Dr. Feneeh's serviee September 20, 1939, at 3 A.M. He was in a state of mild shoek with a temperature of 97°F., pulse 70, respirations 20, and a board-like abdomen with extreme epigastrie tenderness and diminished peristalsis. The patient gave a history of having suffered a sudden onset of severe epigastrie pain radiating to the back, nausea, vomiting and prostration of four hours' duration. Blood pressure was 120/76, urine normal, and white blood eount 16,900. Flouroseopy revealed no free air under the diaphragm or pneumonie proeess. He was prepared for surgery and four hours later at operation no pathological eondition was found. Two days later he developed a right lower lobar pneumonia whieh eleared up with sulfanilamide therapy. His eyes beeame bloodshot. Aurieular fibrillation and taehyeardia, three days later, required digitalization. The eourse was of a progressive asthenia with temperature rising to 105°F., pulse 160, and respirations 40. The blood eount on the sixth hospital day, when he beeame irrational and eomatous, was as follows: Hemoglobin 90 per eent, red blood eount 4,100,000, and white blood eount 15,700. The patient expired on the seventh hospital day. Autopsy examination revealed a hemorrhage 5 em. in diameter into the right adrenal with complete neerosis of the adrenal eortex and brown atrophy of the eardiae museulature. The left adrenal was normal.

ETIOLOGY

There have been many theories proposed as the cause of this disease in the adult. It has been definitely proved that the Waterhouse-Friderichsen syndrome of adrenal apoplexy in infancy and childhood is due to meningococcus septicemia in 60 per cent of the cases and Streptococcus hemolyticus and pneumococcus in the remaining cases. Kempf calls attention to the embryological predisposition to hemorrhage resulting from the physiological involution of the adrenal cortex. Lavenson reports two cases in which regional suppuration caused thrombosis of the suprarenal vein and consequent adrenal hemorrhage. Lavenson

also calls attention to the peculiar blood supply to this organ consisting of three arteries and one vein to the hilus and suggests that simple alteration of the blood supply or blood pressure may be a factor. Severe superficial burns have been followed by hemorrhage as reported by Arnoud, Churton and Dudgeon. Simmonds suggests the presence of hemorrhagic diathesis and hemophilia. Syphilis, convulsions, leukemia and septicemia have been proposed. Trauma has been the inciting factor in cases reported by Canton, Mattei, Seligman, Damon, Chandler, Antonini and our own. Goldzieher and Gordon add to this list stasis due to compression of the vena cava between the liver and vertebral column. Altschule presented a case resulting from the idiopathic thrombophlebitis of the adrenal veins.

PATHOLOGY

Suprarenal hemorrhage may occur unilaterally or bilaterally, the latter being the most common type. Dudgeon has arbitrarily divided cases of suprarenal hemorrhage into three groups, depending upon the degree of glandular involvement: In the first group, the whole gland is converted into a blood sac with occasional extravasation into the surrounding tissues. In the second group, well marked hemorrhage into the medulla occurs with the cortex being spared. These two groups are often associated with a thrombosis of the suprarenal veins and when both glands are involved is usually fatal. The third group consists of scattered hemorrhage into the gland substance, chiefly the medulla, with little or no destruction of the parenchymatous elements. This last type is most frequently noted in the acute infectious diseases, is not usually the cause of death and is not included by some authors in the class of adrenal apoplexies.

Unilateral adrenal hemorrhages are usually of enormous size, the other gland being intact. The right adrenal is most commonly involved, probably because of the anatomical arrangement in which the right adrenal

vein comes directly off the vena cava and the left adrenal vein from the left renal vein. Grossly the adrenal is large, soft and discolored; on section, it presents a dark, homogeneous mass surrounded by a thin layer of hemorrhagic cortical tissue. The vessels to the gland are usually thrombosed. Simmonds found that the thrombi in the central veins and large branches were definitely older than those in the small branches and capillaries, concluding that thrombosis was the primary causal factor in these cases and hemorrhage secondary. Varying amounts of blood surround the gland and the hematoma may be felt through the abdomen. The condition of the other organs is variable, multiple purpuric areas in the abdominal viscera, brain and skin being not uncommon. Microscopically, there is almost complete destruction of the gland substance. Scattered islands of cortical cells and some connective tissue cells of the stroma, may be preserved but scarcely any of the nuclei are recognizable. Hemorrhagic extravasations of varying sizes are dispersed throughout the necrotic tissue.

CLINICAL CLASSIFICATIONS

Clinically, cases of adrenal apoplexy have been classified into five groups. Arnoud recognizes three groups, the first of which is the *peritoneal type* in which there is usually a sudden, severe abdominal pain and profound collapse, associated with vomiting, abdominal distention and mild lumbar and epigastric tenderness. The picture may resemble that of acute hemorrhagic pancreatitis, peritonitis and ilius; yet, the physical signs are vague and the shock is out of proportion to them. The collapse goes on to coma and the patient dies in a few days in profound depression. Such a picture has led to surgical intervention, as was deemed the proper choice in the cases of Bradnitz, Barsoum and our own. The second type, called the *asthenic type*, is characterized by a marked asthenia which progresses to a fatal termination. In the third type, *nervous* symptoms dominate the picture, being characterized by either

delirium, convulsions, coma or a typhoid-like state. Lavenson has suggested a fourth type which includes cases of sudden death of infants in which nothing is found at autopsy but adrenal hemorrhage, and a fifth type in children comprising those cases which are associated with purpura of the viscera and skin. The last type is considered by most writers to be due to the severe toxemia and the adrenal hemorrhage is a manifestation of the general hemorrhagic tendency.

SIGNS AND SYMPTOMS

The signs and symptoms of adrenal apoplexy are many and this makes the diagnosis before autopsy most difficult. These can, however, be divided into two groups according to the physiology of the disease condition: Signs of acute adrenal insufficiency are rapid respirations, hyperpyrexia, rash and petechiae, gastrointestinal disturbances, such as, vomiting, diarrhea, and abdominal pain, and nervous manifestations, such as, twitching, convulsions and coma. Signs attributed to adrenal hemorrhage are shock, collapse, weak irregular pulse, cold extremities, increasing pallor, air hunger, a distended abdomen with pain and infrequently a palpable tumor in one or both kidney areas. The Sargent White line, once thought to be an important sign of adrenal disease, has now been found to be of no significance. The leukocyte count may be high and the blood pressure tends to be low.

DIAGNOSIS

The manifestation of severe abdominal symptoms with few or no physical signs in a patient who presents definite nervous manifestations, profound asthenia and gradual decline in blood pressure should suggest adrenal disease. Materna has suggested the frog pupillary reaction as an intravitam diagnostic aid in the recognition of adrenal intoxication and gives complete directions for the procedure. Unfortunately there is no pathognomonic sign.

TREATMENT

The reports of cases of adrenal apoplexy diagnosed and successfully treated are extremely rare. At the present time, treatment consists of rest, with or without sedation, the injection of adrenalin and a potent adrenal cortical extract, and a maintenance of a normal water balance and normal blood chemistry. Intravenous fluids may consist of either 5 or 10 per cent glucose solution, physiological saline or Ringer's solution. The value of desoxycorticosterone is, as yet, not reported. Blood transfusions are indicated as supportive measures. Blood plasma may be used to counteract the shock. Blood cultures should be taken and when positive, antiserum should be used along with chemotherapy. Surgery, theoretically, offers a little hope in the unilateral adrenal hemorrhage, although no patients have recovered in cases of adults, but it is apparently of no avail in bilateral cases.

CONCLUSION

In reviewing the literature from 1928 to the present time, twenty-two cases of acute adrenal hemorrhage in the adult have been reported.

Two unique cases of unilateral adrenal apoplexy in the adult occurring at Harper hospital have been presented.

An attempt has been made to present a clear-cut, clinical picture of adrenal apoplexy in the light of present day knowledge.

I wish to acknowledge the encouragement and advice of Dr. Plinn Morse, Pathologist to Harper Hospital, and of Dr. A. D. McAlpine, Chief of Surgical Staff of Harper Hospital.

REFERENCES

1. Aegerter, E. E. The Waterhouse-Friderichsen syndrome. J. A. M. A., 106: 1715, 1936.
2. Altschule, M. D. Adrenal apoplexy in man 72 years of age. Am. J. M. Sc., 198: 17, 1939.
3. Antonini, A. A case of traumatic adrenal hemorrhage. Endocrinol. e pat. costit., 6: 183, 1931.
4. Arnoud. Quoted by Lavenson.
5. Ascher, F. A. Case of bilateral adrenal hemorrhage. Gyógyászat, 73: 531, 1933.
6. Barsoum, H. Adrenal apoplexy. Brit. M. J., 2: 972, 1936.
7. Bittorf, A. Zur Kenntnis der Nebennierenerkrankingen. München. med. Wchnschr., vol. 63, 1928.
8. Brunner, T. Massive hemorrhage of adrenals. Deutsche Ztschr. f. Chir., 202: 248, 1927.
9. Chandler, L. R. Bilateral suprarenal apoplexy due to trauma. S. Clin. North America, 14: 1319, 1934.
10. Churton. Quoted by Lavenson.
11. Corcoran, W. J. and Strauss, A. A. Suprarenal hemorrhage in newborn. J. A. M. A., 82: 626, 1924.
12. Damon, L. A. Bilateral suprarenal hemorrhage in epileptic. Psychiat. Quart., 6: 438, 1932.
13. Dudgeon, L. S. The etiology, pathology, and diagnosis of adrenal hemorrhage. Am. J. M. Sc., 127: 134, 1904.
14. Finnegan, F. R. Bilateral massive hemorrhage in instance of hyperfunction of adrenal cortex. Am. J. Digest. Dis. & Nutrition, 2: 504, 1935.
15. Farr, C. E. and Semsroth, K. Suprarenal hemorrhage. Arch. Surg., 15: 627, 1927.
16. Goldzieher, M. A. and Gordon, M. B. The syndrome of adrenal hemorrhage in newborn. Endocrinology, 16: 165, 1932.
17. Goldzieher, M. A. The Adrenals. New York, 1929. MacMillan Co.
18. Grier, M. E. and Russan, B. C. Clinical and pathological presentation of case of suprarenal hemorrhage. Nebraska M. J., 14: 113, 1927.
19. Hall, E. M. and Hemken, L. The adrenal gland, a clinical and pathological study. Arch. Int. Med., 58: 448, 1936.
20. Harris, R. I. Hemorrhage into adrenal capsule and hemorrhage from duodenal ulcer in burn case. Clin. J., 59: 150, 1930.
21. Hasselstrom, E. and Hulten, O. Abdominal symptoms of suprarenal hemorrhage. Upsala läkaref. förh., 34: 229, 1928.
22. Hektoen, L. Death from hemorrhage into suprarenal bodies of boy of eighteen. Tr. Chicago Path. Soc., 8: 87, 1909–1910.
23. Ikhteyman, I. M. Adrenal hemorrhage resulting in death. Klin. med., 10: 330, 1932.
24. Kempf, H. Uber die Bedentung der Nebennierenblutung f. der Ploezlieher. Tod. Vierletjahrschrift Genechlliche Med., 56: 71, 1918.
25. Lavenson, R. S. Acute adrenal insufficiency. Arch. Int. Med., 2: 62, 1908.
26. Loeb, R. F. Glandular physiology and therapy: the adrenal cortex. J. A. M. A., 104: 2177, 1935.
27. Lusk, F. B. and Brumbaugh, A. Non-traumatic hemorrhage of suprarenals. J. A. M. A., 72: 1062, 1919.
28. Materna, L. Autoadrenenintoxikation bei Beidenseitigen Nebennierenblutung. Beitr. z. path. Anat. u. z. allg. Path., 47: 236, 1910.
29. Pearl, F. and Brunn, H. Bilateral suprarenal apoplexy. Surg., Gynec. & Obst., 47: 393, 1928.
30. Rogoff, J. M. Glandular physiology and therapy: the adrenal medulla. J. A. M. A., 104: 2088, 1935.
31. Rosenthal, D. B. A case of acute suprarenal hemorrhage. Brit. M. J., 2: 645, 1933.

32. SACKS, M. S. The Waterhouse-Friderichsen syndrome. *Ann. Int. Med.*, 10: 1105, 1937.

33. SCHRODER, G. Etiology of so-called adrenal apoplexy. *Frankfurt. Ztscbr. f. Path.*, 37: 128, 1929.

34. SELIGMAN, B. Hemorrhage into adrenal in adult with special reference to hyperpyrexia. *M. J. & Rec.*, 135: 209, 1932.

35. SEVERN, A. G. M. Case of acute bilateral suprarenal hemorrhage. *Lancet*, 1: 647, 1923.

36. SIMMONDS, M. Uber Nebennierenblutung. *Virchows Arcb. f. path. Anat.*, 170: 242, 1902.

37. STEWART, G. N. Adrenal insufficiency. *Endocrinology*, 5: 283, 1921.

38. SWINGLE, W. W. Studies of functional significance of suprarenal cortex. *Am. J. Physiol.*, 79: 666, 1927; ibid., 86: 450, 1928.

39. TAYLOR, G. W. Intestinal diverticulosis, pernicious anemia, and bilateral suprarenal apoplexy. *New England J. Med.*, 202: 269, 1930.

IN the upper extremity . . . nonunion in the forearm, and deformity and stiffness at the wrist, are frequently the result of early and injudicious attempts to exercise, manipulate, massage, or use arms and wrists in which fractures have occurred.

From—"Wounds and Fractures"—by H. Winnett Orr (Charles C. Thomas).

MAINTAINING REDUCTION IN OBLIQUE FRACTURES
OF LONG BONES*

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ONE of the fundamental principles in the treatment of any fracture is the maintenance of the replaced fragments in corrected position until callus is formed. In oblique, spiral or badly comminuted fractures of the long bones, in which it is impossible to make the ends of the fragments engage, the maintenance of position has always been a major problem. Unless some form of continued fixation is used, the bones tend to slip after reduction, resulting in overriding, malalignment and shortening. Many methods have been designed to meet this problem, as references to standard textbooks on fractures[1,2,3] will disclose. Many of the methods afford adequate reduction of fractures but have certain disadvantages from the viewpoints of the surgeon, the physical therapeutist and the patient. A few methods, simple and orthopedically sound, have proved to be entirely satisfactory. It is the object of this paper to draw attention to one of the most satisfactory procedures for managing difficult fractures of long bones.

Other methods by which this type of fracture may be reduced and the fragments controlled include operative treatment, traction and suspension. Open operation is not to be recommended, because a simple fracture is thus converted into a compound one with the danger of infection.[4] Operative reduction adds surgical trauma to a severe injury. Furthermore, the forms of internal fixation that are commonly used, such as wire sutures, Lane plates and Parham bands, are foreign materials, whose contact with bone may lead to later complications.[5,6,7] If bone grafts are used to fix the fragments, there is additional trauma and the operation is prolonged. Finally, open reduction necessitates an extensive experience in bone surgery as well as the co-operation of an exceptionally well trained operating team.

Traction and suspension methods are satisfactory in the management of these fractures. To be effective, any form of traction must have certain essentials. Once the traction has been applied, it should remain fixed without the need of constant attention and it should have no injurious effect upon other tissues. In addition, traction methods should be so simple and adaptable to given conditions that they can be used by a practitioner with limited experience in this particular field. Many of the traction methods in use fail to meet these requirements.

In skin traction, for instance, there is always a possibility that the moleskin might slip, regardless of how carefully it has been applied. "Ice tongs" or pins in the bones might become loose and, due to the motion of these foreign materials in the bones, irritation, necrosis and occasionally osteomyelitis may result. Other forms of traction require daily adjustments

to counteract the altered line of pull due to changes in the patient's position. These changes in position may be either volun-

hospital, daily adjustment of all traction cases consumes a considerable amount of the time.
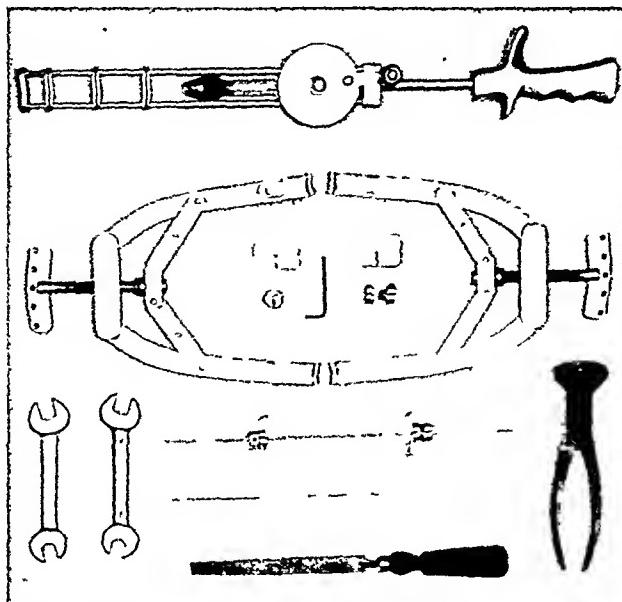
FIG. 1. These commonly used instruments, plus fracture table, x-ray apparatus and plaster of Paris, constitute all the equipment which is required.

tary or necessitated by nursing care. Traction has, in fact, been described as "dynamic energy and must be guided and

Traction methods require long periods of recumbency until sufficient callus has formed to insure the retention of the frag-
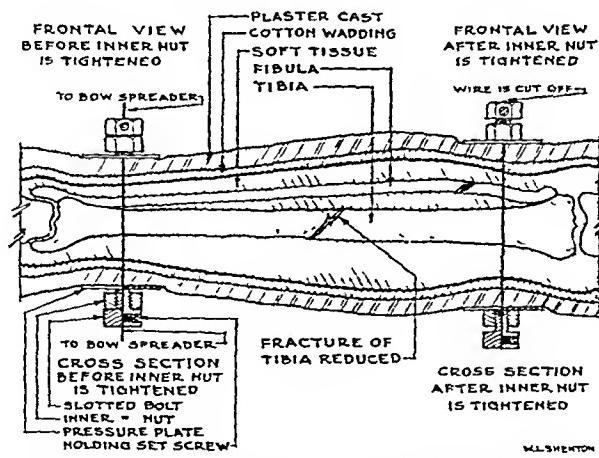
FIG. 2. Diagram showing fracture in horizontal position, as viewed on operating table, giving details of tautening bolts attached to wires.

varied from day to day as the position of the fragments change in response to the forces exerted on them."* In an active

* Key, J. A. and Conwell, H. E. The Management of Fractures, Dislocations and Sprains. 2d ed., p. 84. St. Louis, 1937. C. V. Mosby Co.

ments. This prolonged recumbency results in marked atrophy of the muscles as well as circulatory changes, which interfere with the rehabilitation of the patient. If the traction has been applied through

joints, the changes that take place in their supporting tissues make it difficult to restore complete function. From the pa-

method[11] of treating oblique fractures of the tibia and fibula. Reduction is obtained on a special frame by skeletal traction

FIG. 3. After two attempts at closed reduction elsewhere, patient came to Gouverneur Hospital.

FIG. 4. X-ray made on operating table during reduction.

tient's viewpoint, long periods of hospitalization are an economic burden.

The appreciation of the disadvantages of such methods led to the development of various forms of traction that would maintain the reduced fragments in position and remain "truly fixed."[8] Surgeons interested in the construction of mechanical appliances devised apparatus by which both reduction and adequate maintenance were possible:[9,10] Instrument makers built appliances, such as the Zimmer apparatus, which proved efficacious. Many of these, however, proved complicated and difficult to apply and the results were not always satisfactory. Then, too, the cost of such equipment often precludes its use in small hospitals or by those who seldom treat the fracture.

A stage in the development of fixed traction is exemplified by Böhler's excellent

through the os calcis. Modified Steinman pins are inserted above and below the site of fracture and plaster splints are carefully molded about the pins to hold them fixed. A circular plaster bandage is then applied in which the splints and pins are incorporated. This method of treatment has the advantage of permitting a patient with an uncomplicated fracture to be ambulatory and to bear weight in one week after reduction. On the other hand, Böhler's method, as well as its various modifications, has certain disadvantages in being limited to the treatment of fractures of the leg, requiring a special frame that is limited in use, special type of pins and, finally, a circular plaster casing that is heavy and cumbersome when applied over plaster splints.

Still further efforts to obviate all the difficulties in managing oblique fractures

of the long bones have resulted in the development of several satisfactory methods. One of these, which the writers

FIG. 5. Apparent distraction is due to magnification from the remote placement of the film.

advocate, is based on the use of a small tautening bolt described by Thomson and Ferciot.[12] The results have been so completely satisfactory that the method is to be recommended. It is a simple procedure, based on sound orthopedic principles,[13] that provides for fixed traction. It interferes in no way with the circulation, requires no adjustment from the time of its application and insures protection until healing has been established. From the standpoint of reduction, the method is entirely satisfactory, insuring restoration of both alignment and the length of the extremity. Joint function is preserved.[14] The equipment required, in addition to the tautening bolts, is usually available to anyone, even to those who have a limited amount of fracture work.

METHOD ADVOCATED

Equipment. The materials required are: A fracture or orthopedic table, two Kirschner wires, a drill, two spreaders, a fluoroscope or portable x-ray, plaster bandages, four tautening bolts with pressure plates, two ordinary end wrenches, a wire cutting plier and a file. (Fig. 1.)

Technic. At the Gouverneur Hospital, the emergency care is given by an ambulance or admitting surgeon. The fracture is adequately splinted, hemorrhage is controlled and compound wounds are properly dressed. A roentgenogram is taken to ascertain the exact nature of the fracture. An attending orthopedic surgeon is called. Then, the patient with the injured extremity—still in the original splint —is transported to the operating room. Such handling of a fracture case allows definite, and frequently final, treatment to be completed within three or four hours after the accident.

When there are no complicating factors, the patient, with the limb still in the splint, is placed on the fracture table in the operating room. Appropriate anesthesia is administered. In fractures of the lower extremity, the normal leg is attached to the traction foot piece of the table, which together with the perineal bar provides later countertraction. In fractures of the upper extremity, a body rest acts as the point of countertraction.

With the patient anesthetized and the original splint removed, the skin is prepared in routine manner. The sites for the insertion of the wires should be selected carefully, as the wires must be put in place quickly and at the first attempt. The wires should be so placed in the bone as to avoid the hematoma as well as nerves, blood vessels, epiphyseal regions and the joints. Large bow spreaders are placed on the wires, the surgeon taking care to keep the spreaders as far away from the limb as possible, in order to allow passing a plaster bandage between the spreaders and the skin surface. The spreaders are tight-

ened to render the wires taut. The spreader from the upper wire is attached to the overhead crossbar to make the upper frag-

FIG. 6. Reduction completed; cast applied incorporating wires.

ment stable. If the distal wire has been placed well down the extremity—for example, in the lower tibia or in the os calcis—the spreader from this wire is attached to the fraction foot piece. If such an attachment cannot be made, traction is secured by attaching the extremity to the foot piece in the conventional manner. As traction is placed on the injured limb, countertraction is simultaneously instituted. The fragments are manipulated into position. If the fracture is a compound one, the Orr method[15] or some other appropriate treatment is carried out. The position of the fragments is checked by the fluoroscope or by a roentgenogram.

Following reduction, a plaster casing incorporating both wires is applied. It should extend far enough above and below the site of the fracture to secure immobilization. The plaster is flattened around the wires where the slotted pressure plates will be applied later. When the casing is

hardened, all traction is released, the spreaders are bandaged to the casing and the patient is put to bed with the limb

FIG. 7. The pressure plates and tautening bolts attached outside of cast.

elevated on pillows. No suspension is necessary. Within the next forty-eight hours, a second roentgenogram is taken to verify the position of the fragments. If the reduction is satisfactory, the pressure plates are placed over the wires, the tautening bolts are applied snugly against the plates and the set screws are tightened in place against the pressure plate to insure the tautness of the wire. (Fig. 2.) The spreaders are then removed. The protruding wires are cut flush with the head of the bolts to obviate any danger of injury to the patient or attendants. (Figs. 3 to 8.) As soon as the patient's general condition warrants, he may become ambulatory with the aid of crutches. (Fig. 13.)

Results. There has been no case of nonunion and no appreciable shortening in the cases which it has been possible for us to follow to the completion of treatment. Any persisting deformity has been so slight
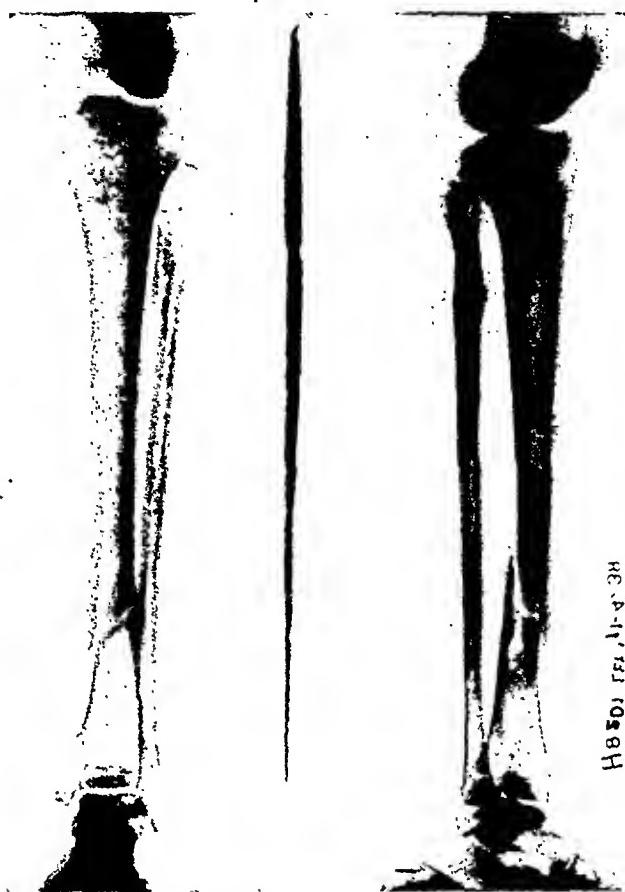
FIG. 8. Eight weeks after reduction; sufficient callus to
maintain reduction. Wires are removed.

FIG. 9.

FIG. 10.

FIGS. 9 AND 10. Two cases each showing reduction with tautening bolts attached to wires. Reduction
maintained by fixed skeletal traction. Tautening bolts assure continuous tension of wires.

that it has not interfered with the return of normal function. Late pain has not been a conspicuous complaint. In severe fractures of the lower tibia and fibula, the usual protracted periods of healing were encountered.

In only one case was there a complication from the method. This was a persistent sinus at the site of the wire. As a rule, the sites of penetration of the wires healed promptly.

ADVANTAGES OF THE METHOD

By this method, a satisfactory reduction is obtained and the maintenance of the replaced fragments is insured, even in the most difficult fractures. The fundamental principles of the treatment of fractures are observed, in that correct alignment is obtained without subjecting injured tissues to further trauma. The plaster casing and the tautening bolts insure immobilization and prevent motion between the wires and the bones, which motion is at times responsible for bone necrosis and osteomyelitis.

The method is simple and the required equipment is usually available. Continuous, fixed countertraction is provided by the fracture table, thereby eliminating the

need of both special countertraction on the upper fragment and an additional support for the knee.

FIG. 11. Lateral view of fracture shown in Figure 12.

FIG. 12. Anteroposterior view of fracture shown in Figure 11.
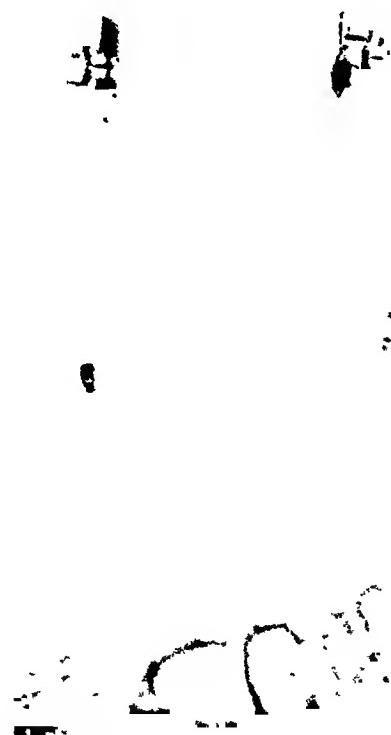
FIG. 13. Patient ambulatory with tautening bolts attached outside of cast.

Early activity stimulates the formation of callus, shortening the period of immo-

bilization. Weight bearing without protection is possible as early in this method as following any other treatment.

To the physical therapist, the great advantage of this method is the preservation of muscle tone and circulation. This is accomplished by early ambulation permitting muscular activity and frequent changes in the position of the extremity. As a result, when the patient comes to the physical therapeutist for treatment, he is in the best possible condition, in contrast with the patient who has a sluggish circulation and muscle atrophy as the result of prolonged recumbency. Early activity stimulates the formation of callus and thereby shortens the period of immobilization. It is sometimes possible to remove part of the casing after the first few weeks to permit motion of adjacent joints. In view of the patient's good condition and the advantage of beginning physical therapeutic measures early, the physical therapeutist is able to rehabilitate the patient in the shortest possible time and to restore the maximum function.

SUMMARY

A simple method has been described that insures both the reduction and the maintenance of position in oblique, spiral and comminuted fractures of the long bones. One of the great advantages of the method is its simplicity, which makes it possible for any doctor to use the procedure, even one having a minimum of equipment at his disposal.

By the use of this method, the circulation, muscle tone and joint function are preserved, thereby aiding the physical therapeutist in rehabilitating the patient and restoring normal function.

REFERENCES

1. KEY, J. S. and CONWELL, H. E. The Management of Fractures, Dislocations and Sprains. 2d ed. St. Louis, 1937. C. V. Mosby Co.
2. WILSON, P. D. Management of Fractures and Dislocations. Philadelphia, 1938. J. B. Lippincott Co.
3. MAGNUSON, P. B. Fractures. 2d ed. Philadelphia, 1936, J. B. Lippincott Co.
4. ELIASON, E. L. and NORTH, J. P. End results in fractures of the shaft of the femur. *J. A. M. A.,* 109: 845, 1937.
5. MUMFORD, E. B. Internal fixation of fractures. *Surg., Gynec. & Obst.,* 58: 194, 1934.
6. NORTHFIELD, D. W. C. On the fate of metallic foreign bodies introduced into the tissues in the treatment of fractures. *Guy's Hosp. Rep.,* 86: 159, 1936.
7. VENABLE, C. S. Osteosynthesis in the presence of metals. *South. M. J.,* 31: 501, 1938.
8. ORR, H. W. The treatment of fractures by means of skeletal devices. *J. A. M. A.,* 98: 947, 1932.
9. ANDERSON, ROGER. Ambulatory method of treating femoral shaft fractures utilizing fracture table for reduction. *Am. J. Surg.,* 39: 538, 1938.
10. CARTER, R. M. Fixed skeletal traction in fractures of the leg. *J. Bone & Joint Surg.,* 15: 737, 1933.
11. BÖEHLER, LORENZ. The Treatment of Fractures. 4th ed. Baltimore, 1935. Wm. Wood & Co.
12. THOMSON, J. E. M. and FERCIOT, C. F. A tautening bolt for use with Kirschner wire when plaster of paris casts are used in the treatment of fractures. *J. Bone & Joint Surg.,* 18: 245, 1936.
13. JONES, SIR ROBERT and LOVETT, ROBERT W. Orthopedic Surgery. 2d ed. Baltimore, 1933. Wm. Wood & Co.
14. ORR, H. W. Early and complete immobilization as a factor in the preservation of joint function in the treatment of fractures. *Am. J. Surg.,* 35: 146, 1921.
15. Ibid. Osteomyelitis and Compound Fractures and Other Infected Wounds. St. Louis, 1929. The C. V. Mosby Co.

THE DIAGNOSIS OF LOW BACK PAIN OF ORTHOPEDIC ORIGIN*

AN ANALYSIS OF SIXTY-TWO CASES

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IN spite of an extensive literature on the etiology and diagnosis of low back pain, this symptomatic disturbance continues to present itself all too frequently as a perplexing problem. Many outstanding contributions have set forth methods of etiologic classification and numerous tests and signs have been described to further accurate diagnosis. Roentgenologic technic has been modified and this medium has been used as a means of comparison with clinical findings in order more certainly to appraise the importance of the history and physical signs.

While relief of discomfort and return of function constitute the ultimate purpose of treatment, the cause of the low back pain must be determined if the proper therapeutic measures are to be applied promptly. Essentially, it must be decided whether the origin of the patient's pain is bony, articular, nervous, musculoligamentous or referred from some distant and apparently unrelated physiologic system. An attempt is then made to determine the exact area of the causative lesion and its pathologic type. It is here that the greatest difficulty arises, in spite of the array of diagnostic procedures which have been suggested from time to time. Many of these have been extremely helpful. Others have merely added to the confusion. Probably every one has added an additional hazard, namely, that of a false sense of diagnostic security. It has already been pointed out that there is no single pathognomonic sign of any definite lesion causing low back pain. In this study an attempt has been made to estimate the value of clinical signs and symptoms in the exact diagnosis of low back pain which is of orthopedic origin.

MATERIAL

These observations were made on a series of patients who presented themselves at the Backache Clinic. Of seventy consecutive patients, sixty-two cases of back pain of orthopedic origin were thoroughly studied. There were forty-four females and eighteen males. The ages varied between seventeen and seventy-three. There were three in the second decade, seven in the third, fourteen in the fourth, twenty-four in the fifth, eight in the sixth, four in the seventh and two in the eighth. The duration of symptoms ranged between one week and twenty years. In three cases the complaints were present for less than a month, in nine between one and five months, in three between six and twelve months and in forty-seven for over a year.

All cases had detailed study of the symptomatology and physical signs. The important studies in the symptomatology included the relationship of trauma and infection, the history, location, type, mode of onset and radiation of pain, together with the factors producing relief and exaggeration, the relation of pain to menses, the location of paresthesia and the character and location of stiffness with the effects of activity and change of position on this complaint.

The emotional factor was estimated in all cases. A detailed physical examination was made in the sitting, standing, prone, supine and side positions. Observations were made regarding the effect of posture on pain, alteration in spinal curves, range of spinal motion with production of pain, muscle spasm, condition of leg reflexes, equality of leg length, atrophy, muscular weakness, change in sensation, and areas of back, buttock, abdominal, groin and leg tenderness. Rectal examination was done in all cases. General posture and static weakness of the feet were appraised and a search was made for nodules and masses in the back and buttock. Special diagnostic tests included straight leg raising with and without dorsiflexion of the foot, Ober, Gaenslen, Nachlas, fabere and Yergason tests and the effect produced by special motions and forces such as hyperflexion and hyperextension of the back, compression of the anterior-superior spines, lateral leg bending, internal rotation of the hip, hyperextension of the hip, iliac twist and coccygeal pressure.

All patients had complete roentgenologic examinations including views of the pelvis, antero-posterior and lateral views of the dorsal and lumbar spine, a lateral view focused over the lumbosacral joint, and oblique views of the lower lumbar region. Studies were made to eliminate the possibility of urologic, gynecologic and gastrointestinal causes of low back pain. Routine blood and urine studies were made on all patients. The possibility of foci of infection in the teeth, tonsils, prostate or uterine cervix was investigated. A neurologic opinion was obtained when indicated and in one case lipiodol was used for a myelogram.

ANALYTICAL STUDY

DIAGNOSIS

The clinical diagnoses were made in the usual manner after completion of the detailed studies and were divided into two classifications: first, as to the area of the causative lesion and, second, as to the type of pathologic process thought to exist. In the area classification, thirty-two were thought to be lumbar, thirteen lumbosacral, three dorsolumbar, nine sacroiliac, two lumbar and lumbosacral and three lumbar and sacroiliac. In the type classification, forty-one were thought to be due to sprain or myofascitis, fourteen to hypertrophic arthritis, three to hypertrophic arthritis and strain, two to atrophic arthritis and strain, one to protrusion of a disc and one to osteochondritis (sacroiliac).

While a definite organic lesion was thought to be present in all of these cases, there was a significant functional element in twenty-one. In forty-one it was believed that the emotional make-up of the patient played no part whatever in the complaints.

TRAUMA

There were no acute traumatic cases such as are encountered in industrial work. The great majority of our patients had complaints of long duration and in only eight cases was there a history of an injury at the time of onset of the back pain. In four of these there was the history of a back strain and in four a fall on the back. In an additional three cases the patients recalled a fall on the back some time prior to the onset of symptoms and apparently unrelated to them. In fifty-one cases there was no history of any form of related trauma.

INFECTION

In thirty-eight patients various possible foci of infection were discovered. These occurred in the teeth in six patients, in the tonsils in fourteen, the urinary tract in two, the pelvis in two, the sinuses in one and there were multiple areas of infection present in thirteen. It was, nevertheless, our belief and the belief of our consultants that in only two of these cases was there a definite connection between the infected area and the patient's complaints. One of these was tonsillar infection and the other dental.

ASSOCIATED CONDITIONS

In fourteen patients there were associated conditions which might give rise to pain in the lower back. In eight there was a gynecologic condition present, in one an inguinal hernia, in four urologic lesions and in one a malignancy of the bowel. In all of these patients, however, we were of the opinion that there was definite and adequate orthopedic cause for the patient's complaints.

CHARACTER OF PAIN

In describing the pain, eighteen patients stated it was sudden in onset, while forty-four described it as gradual. Concerning the character of the discomfort, it was apparently dull and aching in thirty-eight, sharp and shooting in eleven and a combination of the two in thirteen. The pain came in definite attacks with free intervals in nine cases, it was steady although varying in severity in forty-two, and in eleven there was a combination of severe attacks with less severe pain in the intervals.

Relief of the discomfort was produced by rest in fifty-two of the sixty-two cases. Seven patients stated that the pain was constant and that there was no relief by any method. There was relief by lying on the back in twenty-one cases, by lying on the side opposite the discomfort in six, by lying on the side of the discomfort in four, by the erect position in two, by lying on the abdomen in four, by flexing the knees in one case and by any change of position in three cases.

Regarding exaggeration of the pain, forty-nine patients stated that it was more severe upon any form of activity. In fourteen it was increased by forward bending, in one by lying on the side of the discomfort, in three by sitting, in two by the erect posture and in six the discomfort was constant. Simple change from one position to another caused increased pain in thirty-eight cases, while change of weather was apparently an exaggerating factor in

twenty-five cases. The discomfort was increased at the time of the menses in eight cases, while in thirty-six there was no apparent change at these times.

A study was made of the relationship between the character of the low back pain and the diagnosis. It was soon apparent that the various types, methods of relief and of exaggeration of pain were noted proportionately in the several diagnostic groups and were of no significant assistance in determining either the site or type of the pathologic lesion. It was noteworthy that change of weather was an exaggerating factor in similar proportion in the cases due to strain and in those due to arthritic changes.

NUMBNESS AND STIFFNESS

Fifteen patients presented subjective changes in sensation in the leg and one in the buttock. In forty-seven no disturbances of this nature were noted.

Subjective stiffness of the back was present in twenty cases and of the hip in two cases. The stiffness was noted only in the morning on arising in sixteen cases and was a fairly constant complaint in six cases. In the patients who complained of stiffness, this sensation was exaggerated by change from one position to another in nineteen, whereas in three change of position had no effect. In seventeen, the stiffness seemed to decrease with activity, while in five activity produced no change.

There was no definite relationship between the incidence of these complaints and the clinical diagnosis. There was no significant difference in the frequency with which these symptoms were found in the various diagnostic groups. Stiffness of the back was apparently more frequently noted in lumbosacral cases than in any of the others, but it was found in similar proportions of the cases of strain and those due to arthritis. Increase of stiffness by change of position and decrease upon activity were also noted equally in these latter groups.

AREA OF COMPLAINTS

In forty-five cases the patients complained of pain "in the lower back." This included the center of the lower back, one side, or both sides. In ten cases the complaint was "in the buttock," either unilateral or bilateral. In seven cases the pain was noted "in the back" or "in the middle of the back," the impression being given that it was not low in the back, although no case of pain in the dorsal region has been included in this series.

There was an interesting relationship between the area of complaints and the diagnoses. In the area classification, in *all* the lumbosacral cases the complaint was of pain in the lower back. Of the sacroiliac cases, nine of twelve patients complained of pain in the lower back, with only three in the buttocks. Of the thirty-two lumbar cases, twenty patients complained of pain in the lower back, seven of pain in the buttock and five of pain in the middle of the back. All patients complaining of pain in the middle of the back were either lumbar or dorsolumbar cases in origin. In the type classification, the complaint of pain in the middle of the back was found in four of fourteen cases of hypertrophic arthritis and in only one of forty-one cases due to strain.

LATERALITY OF COMPLAINTS

In fifteen patients the back pain was present only on the right side and in fifteen it was only on the left. Seventeen patients described it as bilateral, while fifteen stated that it was directly in the middle of the back in the line of the spinal column. In relation to the area of the lesion, the pain was unilateral in seventeen of thirty-two lumbar cases, ten of twelve sacroiliac cases and only three of fifteen lumbosacral cases. The complaint was either bilateral or in the midline of the spine in fifteen of thirty-two lumbar cases, two of twelve sacroiliac cases and twelve of fifteen lumbosacral cases. There was no significant relationship between the laterality of complaints and the type of existing pathology.

REFERRED PAIN

In thirty-five patients the pain was confined to the lower back, but in twenty-seven there was radiation to one or both lower extremities. In twenty-four the radiation was unilateral and in three it was bilateral. In twenty cases the radiation of pain was sciatic in distribution, in one case it was in the area of the outer thigh, in three the front of the thigh, in one the region of the groin and in two cases the reference occurred in the lower abdominal quadrant.

In relation to the area of the causative lesion, sciatic radiation of pain was noted in seven (22 per cent) of the lumbar cases, in four (27 per cent) of the lumbosacral cases and in nine (75 per cent) of the sacroiliac cases. The dorsolumbar cases presented no area of radiating pain. The patients with radiation to the outer thigh, front of the thigh, groin and abdomen were all thought to have lumbar lesions. In the cases with bilateral radiation of pain, one was lumbar, one lumbosacral and one sacroiliac. There was no significant difference in the relationship between the various types of causative lesions and the radiation of pain. Sciatic radiation was present in 30 per cent of the cases due to strain or myofascitis and in 30 per cent of the cases due to hypertrophic arthritis. The protruded fifth lumbar disc and the sacroiliac osteochondritis both produced sciatic pain.

LIMITED, PAINFUL SPINAL MOTIONS

In forty-three cases there was no significant limitation of spinal motion. Limitation, when present, was chiefly on anterior bending in six, on posterior bending in three, bending to the side opposite the painful area in one and limitation in all directions was noted in seven. In nine cases, anterior bending in the sitting position was definitely freer and less painful than in the erect posture. Limitation of a certain direction of spinal motion seemed

to bear no definite relationship to the diagnosis except that cases of strain seemed to be accompanied by limitation in one direction, either anterior or posterior, while those due to hypertrophic arthritis were more apt to have limitation in all directions. Similar proportions of these two groups presented no limitation whatsoever.

Improvement in the range and comfort of anterior bending occurred in the sitting position in five of twelve sacroiliac cases, two of thirty-two lumbar cases and two of fifteen lumbosacral cases.

Sixteen patients complained of no pain on spinal motion. In twenty, pain was noted in the lumbosacral area, in eighteen it was present in the buttock or posterior sacroiliac area, while in seven pain was lumbar in distribution. Leg pain was produced in only one patient upon spinal bending. Lumbosacral pain was produced in eight of fifteen lumbosacral cases, eleven of thirty-two lumbar cases and in only one of twelve sacroiliac cases. Sacroiliac pain was produced in nine of twelve cases thought to be sacroiliac in origin, in three of fifteen lumbosacral cases and in six of thirty-two lumbar cases. Lumbar pain was noted only in lumbar and dorsolumbar cases. There was no definite relationship between pain on motion and the type of causative lesion.

Passive, forced thigh flexion was painful in seven of fifteen lumbosacral cases, three of thirty-two lumbar cases and three of twelve sacroiliac cases. In all cases in which this manipulation was painful, the condition was thought to be due to strain.

POINTS OF TENDERNESS

In eight cases there were no areas of tenderness in the back or buttock. In nineteen cases there was tenderness at a single anatomic area. Tenderness was present at the lumbosacral joint in nine, over the lumbar spinous processes in three, over the posterior superior iliac spines in four, over the paraspinal lumbar muscles in two and over the lumbosacral facets in one.

In by far the largest number of patients the areas of tenderness were multiple. In general, there was no direct relationship between the area of the lesion and the points of tenderness. However, in three cases with lumbar spinal tenderness alone, all were thought to have lumbar lesions, and all were diagnosed hypertrophic arthritis. In five cases in which there was chiefly sciatic notch tenderness in conjunction with lesser points of tenderness elsewhere, all were diagnosed as sacroiliac conditions and the causative lesion was thought to be a strain.

REFERRED TENDERNESS

In addition to the areas of tenderness of the back and buttock, there were in nine patients additional tender areas which were thought to be due to referred skin sensitivity secondary to the back condition. This referred tenderness was present in the abdomen and groin alone in three cases, in the thigh and leg alone in two cases and in multiple areas in four cases. There was no relationship between the area or the type of the causative lesion and the area of referred tenderness which it produced.

There was similarly no parallel between the patients' complaints of radiation of pain and the type of referred tenderness. In five cases in which there was no radiating pain, areas of referred tenderness were determined. In only one patient with definite sciatic radiation of pain was there referred tenderness in the sciatic distribution. In sixteen patients with sciatic radiation there was no referred tenderness, in two the tenderness was in the abdomen and groin and in one it existed in multiple areas.

ROENTGENOLOGIC FINDINGS

The roentgenograms revealed lumbosacral anomalies including asymmetrical facets in twenty-eight cases, hypertrophic arthritis in thirty-seven, atrophic arthritis in one and scoliosis in eighteen. The lumbar curve was increased in seven and reduced in eleven. There was narrowing of the

intervertebral discs (excepting the lumbosacral disc) or vertical herniation of the nucleus in eight cases. Bone density was decreased in four cases. Developmental changes consisting of epiphysitis, osteochondritis and associated ligamentous calcification were noted in ten patients.

Posterior narrowing of the lumbosacral intervertebral disc was present in thirteen cases. Posterior displacement of the fifth lumbar vertebra was noted in four patients. The lumbosacral articular facets presented blurring or narrowing in seventeen cases and sclerosis in four cases. In four patients the roentgenograms revealed no abnormal findings.

Dorsal changes occurred in the roentgenograms in thirty cases, dorsolumbar changes in twenty-eight, lumbar changes in forty, lumbosacral changes exclusive of anomalies in eighteen and sacroiliac changes in six cases.

There was no definite relationship between the clinical diagnoses and the areas on the roentgenograms showing the greatest abnormality. Thus, of twenty-eight patients showing lumbosacral anomalies in the roentgenograms, only eight were diagnosed as having lumbosacral lesions. Conversely, of thirty-two patients with the diagnosis of lumbar lesions, only twenty showed this area to be the one principally involved on the roentgenogram. Of thirteen lumbosacral lesions this area was principally involved in six. Of nine sacroiliac lesions, the sacroiliac joint showed the greatest change in the roentgenogram in only one case.

LEG REFLEXES

The patellar reflexes were considered normal in all cases. The Achilles reflexes were unilaterally absent in three cases and they were diminished in two patients, one unilaterally and one bilaterally. In relation to the area of pathology, altered reflexes were noted in four lumbosacral cases and one sacroiliac case. In relation to the type of pathology, four were noted in conditions due to strain and one in the

case of protruded intervertebral disc. The patient with bilateral diminution of Achilles reflexes was diagnosed as a lumbosacral strain.

STRAIGHT LEG RAISING

Straight leg raising was normal and painless in forty-six patients. There was unilateral painful limitation in eight cases and bilateral painful limitation in four cases. In four patients the range was normal, but the manipulation produced pain at the lumbosacral region in two cases and in the buttock in two cases. Limited painful straight leg raising occurred in five of thirty-two lumbar cases, in five of fifteen lumbosacral cases and in six of twelve sacroiliac cases. The very great majority of cases with limited straight leg raising were thought to be due to strain. It was noted in the protruded intervertebral disc and the sacroiliac osteochondritis. In two patients straight leg raising on both sides was limited and caused pain only on the side of the complaints. Both of these cases were thought to be sacroiliac in origin.

Dorsiflexion of the foot caused an increase in pain on straight leg raising in three of the sixteen cases. In one patient with negative straight leg raising, dorsiflexion of the foot at the normal limit produced pain in the lower back. In these four cases with pain on dorsiflexion of the foot, one was lumbosacral, one lumbar and two sacroiliac. Three occurred in cases due to strain and one in the protruded intervertebral disc.

LEG LENGTH

There were forty-nine patients with equal leg length. In thirteen cases there was asymmetry, the right leg being shorter in ten and the left leg in three. The asymmetrical cases were noted in all of the groups of the area classification in similar proportion, but it is noteworthy that in the type classification twelve were in cases thought to be due to strain and one was in the case of protruded disc. There

was no asymmetry in the cases due to arthritic changes. There was no relationship between the side of the leg shortening and the laterality of the patient's complaints.

MUSCLE POWER AND SENSATION

Muscle power of the legs was normal in all cases. While many patients presented subjective changes in sensation of the extremities, actual diminution of sensation in the thigh and leg was noted in only two cases. In neither of these did the sensory changes correspond to any definite cutaneous nerve distribution. One of the cases was diagnosed sacroiliac strain and the other lumbar hypertrophic arthritis.

ATROPHY

Atrophy of the lower extremities was determined by circumferential measurements at the upper margin of the patella and at points six inches above and below it. Atrophy was considered significant only if there was a difference in measurement of at least three-fourths inch in the thigh, one-half inch above the patella or one-half inch in the calf. In forty-one cases no atrophy was noted. There was atrophy of the thigh in seven cases, of the calf in nine, of the thigh and calf in four, and in one patient there was atrophy of the thigh with contralateral atrophy of the calf. The atrophy was right-sided in twelve, left-sided in eight, and contralateral in one case. There was no significant relationship between atrophy and either the area or type of the causative lesion. There was similarly no relationship between atrophy and the laterality of symptoms. Of six cases in which the patients' complaints were right-sided, atrophy was present in the right lower extremity in three cases and in the left in three cases. A similar situation existed when the complaints were left-sided.

Of the five patients with altered Achilles reflexes, three presented no atrophy. In one there was atrophy of the calf and in another atrophy of the thigh and calf.

In six patients presenting referred leg or abdominal tenderness there was no atrophy. In the remaining three, atrophy was noted. In neither of the two cases in which there were objective changes in sensation of the extremities was atrophy seen to co-exist. There was no relationship between atrophy and inequality of leg length.

POSTURE AND FOOT STRAIN

In twenty-nine cases posture was considered essentially normal. In thirty-three it was sufficiently faulty to be suspected of playing a part in the etiology of the low back pain. Definite foot strain was present in thirty cases. The element of faulty posture was noted to be distributed evenly in the various groups of the area classification and there was no significant relationship to the type of causative lesion.

SPECIAL DIAGNOSTIC SIGNS

The Ober sign (abduction spasm or contracture with the hip in abduction and extension, the patient lying on the opposite side with the hip flexed) was positive in only one case. This patient was diagnosed as having a combined lumbar and sacroiliac strain.

The Nachlas sign (back pain upon hyperflexion of the knee with the patient prone) was not considered positive in any of our cases. The Yergason chair test (pain in the buttock on stepping upon a chair with the opposite foot) was similarly productive of no information.

Definite sacroiliac tenderness on rectal examination was noted in only three cases. Two were diagnosed as sacroiliac strain and one as a lumbar strain. Lateral leg bending, iliac twist and lateral compression of the iliac bones were of no assistance in arriving at a diagnosis.

The fabere test (flexion, abduction, external rotation, and extension of the hip) was positive in six cases. The positive cases were distributed throughout the groups of the area classification. In relation to the type of the lesion, the test was positive only in cases due to strain.

Limited painful, internal rotation of the hip was noted in two cases. Both cases were due to strain, one being lumbar and the other lumbosacral.

The Gaenslen sign (pain on hyperextension of the hip with the pelvis fixed by flexion of the opposite thigh) was positive in thirteen cases, unilateral in eleven and bilateral in two. The sign was positive in five of thirty-two lumbar cases, three of fifteen lumbosacral cases and five of twelve sacroiliac cases. It was positive in eleven cases of the forty-one thought to be due to strain and in one of the fourteen which were attributed to hypertrophic arthritis. The other positive sign was in the case of protruded intervertebral disc. In only four of the thirteen cases with a positive Gaenslen sign was this manipulation productive of pain in the area of the patients' complaints. In only five cases was the pain produced in the area in which the causative lesion was thought to exist.

The hyperextension test (pain on hyperextension of the hip with the opposite hip extended) was positive in seventeen cases, eleven unilateral and six bilateral. The test was positive in similar proportion in the various groups of the area and type classification. In nine cases this test produced pain in the area of the patients' complaints. In only five was the pain produced in the area of the causative lesion.

SUMMARY

A clinical study of sixty-two patients with low back pain of orthopedic origin resulted in the following observations:

1. Acute trauma played a minor rôle in the etiology of these cases.

2. Foci of infection were considered of little importance as causative factors.

3. The character of the pain, its mode of onset and methods of exaggeration and relief were of no assistance in determining the exact area or type of the causative lesion. Change of weather was an exaggerating feature in equal proportions in cases due to arthritis and those due to strain. Practically all were relieved by rest. The

same number were relieved by lying on the painful side as on the opposite side. The majority of females found no increase in pain at the time of the menses.

4. Complaints of numbness and stiffness were of no assistance in arriving at the diagnosis. Stiffness was noted in similar proportions in cases due to both arthritis and strain. Stiffness occurred somewhat more frequently in lumbosacral lesions.

5. Regarding the area of the patients' complaints, all lumbosacral cases complained of pain in the lower back or center of the lower back. Of the sacroiliac cases, many more complained of pain in the center of the lower back than of pain in the buttock. All patients complaining of pain in the middle of the back had lesions which were lumbar or dorsolumbar. Pain in the middle of the back was noted almost exclusively in cases due to hypertrophic arthritis.

6. The greatest number of patients constituting sacroiliac cases complained of unilateral pain. The greatest number of patients in the lumbosacral cases complained of midline or bilateral pain. There was no relationship between laterality of complaints and the type of causative lesion.

7. Sciatic radiation of pain was noted in 22 per cent of the lumbar cases, 27 per cent of the lumbosacral cases and 75 per cent of the sacroiliac cases. Radiation to the outer thigh, front of the thigh, groin and abdomen was noted in lumbar cases only. The three dorsolumbar cases presented no radiation of pain.

8. The direction of limitation of spinal motion did not indicate the area of the lesion, but cases of strain were more likely to produce limitation in either the anterior or posterior direction, while arthritic cases were more apt to produce universal limitation of motion. Improvement in range and comfort on anterior bending in the sitting position did not definitely indicate but suggested a sacroiliac cause of the complaints. The area of the pain produced on spinal bending did not consistently represent the area of the causative

lesion. Pain on forced thigh flexion was noted in cases due to lumbar, sacroiliac or lumbosacral lesions, but was more frequently seen in the latter group. These cases almost invariably had a strain as the type of causative lesion rather than arthritic changes.

9. Most patients presented multiple points of tenderness. Tenderness was found most frequently at the lumbosacral joint, the posterior, superior iliac spines and in the paraspinal muscle areas. The areas of tenderness bore no definite relationship to the area or type of the lesion. Three cases with lumbar spinal tenderness alone were all diagnosed lumbar hypertrophic arthritis. Five cases with tenderness chiefly in the sciatic notch with lesser points of tenderness elsewhere were diagnosed as sacroiliac strain.

10. There was no relationship between areas of referred tenderness and the area and type of the lesion. Referred tenderness was apparently not related to the areas of referred pain.

11. There was no definite relationship between the clinical diagnoses and the areas on the roentgenograms showing the greatest abnormality. Great caution must be used in interpreting a given roentgenologic abnormality as the cause of the low back or sciatic pain.

12. Altered Achilles reflexes were noted chiefly in lumbosacral cases. All were found in cases of strain and the one case of protruded intervertebral disc.

13. Limited painful straight leg raising was of no assistance in determining the area of the lesion, but in the great majority of cases in which it was positive, the condition was thought to be due to strain. In cases of bilateral limited straight leg raising, the production of pain on the side of the complaints by raising the opposite leg suggested a sacroiliac lesion. The added test of dorsiflexion of the foot in the straight leg raising procedure was of no further aid in diagnosis.

14. There was no relationship between muscular atrophy and the diagnosis, altera-tion in reflexes, laterality of complaints, areas of referred tenderness or inequality of leg length.

15. The finding of faulty posture, while suggestive as a factor in the low back pain, was of no assistance in determining the area or type of the causative lesion. Inequality of leg length, however, was noted entirely in cases thought to be due to strain.

16. The Nachlas and Yergason tests were negative in all patients in this series. The Ober test, rectal examination, fabere test, and painful, limited internal rotation of the hip were of no assistance in determining the diagnosis.

17. The Gaenslen sign was positive in similar proportion in all of the groups of the area classification, but it was found almost invariably in cases due to strain. It was of no value in reproducing the area of the patients' complaints or in suggesting the anatomic area at fault. The hyperextension test was similarly of no assistance in diagnosis of the area or type of the lesion.

18. There is apparently no clinical sign, symptom, or special test, and no combination of them, which can be reliably considered as diagnostic of either the area or type of the causative lesion. Certain observations may be considered suggestive of a diagnosis.

19. The differentiation is probably almost entirely of academic interest. If intraspinal, osseous, neoplastic and remote causes are eliminated, the remaining 90 per cent of cases of low back and sciatic pain will be found to be muscular, intermuscular, articular or ligamentous in origin. Of these, regardless of the exact type or area of the causative lesion, 90 per cent will be relieved by identical, conservative, therapeutic procedures. The importance of exact diagnosis as to the area and type of the causative lesion in these strictly orthopedic cases is, therefore, limited to the 10 per cent or less which require operative procedures, such as fasciotomy, myotomy or arthrodesis to obtain relief.

REFERENCES

1. Aycock, C. L. Lumbo-sacral backache. *New England J. Med.*, 200: 502-608, 1929.

2. Badgley, C. E. Clinical and roentgenologic study of low back pain with sciatic radiation - clinical aspects. *Am. J. Roentgenol.*, 37: 353-360, 1937.

3. Barr, J. S. The relationship of the intervertebral disc to back-strain and peripheral pain (sciatica). *Surgery*, 4: 1-12, 1938.

4. Burchell, L. G. The treatment of disabilities resulting from low back derangements. *J. Bone & Joint Surg.*, 12: 325-332, 1930.

5. Brandt, L. Mechanics of the physical signs in lower trunk injuries. *Surg., Gynec. & Obst.*, 60: 802-817, 1935.

6. Carus, L. J. The anatomy, physiology, and anomalies of the spine. *Radiology*, 9: 219-234, 1927.

7. Comroe, L. L. The pathogenesis of low back pain. *West Virginia M. J.*, 35: 105-115, 1939.

8. Danforth, M. S. and Wilson, P. D. The anatomy of the lumbosacral region in relation to sciatic pain. *J. Bone & Joint Surg.*, 7: 109-160, 1925.

9. Dickson, F. D. Low back injuries with particular reference to the part played by congenital abnormalities. *South. M. J.*, 29: 363-371, 1936.

10. Fay, J. W. Backache, lumbago, pain in the lower part of the back. *Arch. Surg.*, 27: 189-202, 1933.

11. Freiberg, A. H. Sciatic pain and its relief by operations on muscle and fascia. *Arch. Surg.*, 34: 337-350, 1937.

12. Freiberg, J. A. Low back pain. *J. A. M. A.*, 113: 2105-2108, 1939.

13. Ghormley, R. K. The diagnosis and treatment of low back disability. *M. Clin. North America*, 21: 803-907, 1937.

14. Gaenslen, F. J. Low back pain. *Indust. Med.*, 4: 105-111, 1935.

15. Goldthwait, J. E. The lumbosacral articulation: an explanation of many cases of "lumbago," "sciatica," and paraplegia. *Boston M. & S. J.*, 164: 365-372, 1911.

16. Grossman, M. and Krischner, M. The sciatic syndrome. *Arch. Neurol. & Psychiat.*, 21: 398-412, 1929.

17. Hallock, H. The diagnosis and treatment of low back pain with sciatica. *S. Clin. North America*, 17: 251-277, 1937.

18. Hauser, E. D. W. Sciatic neuralgia—a clinical entity. *J. A. M. A.*, 102: 1465-1467, 1934.

19. Henry, M. O. An analysis of 100 consecutive cases of back strain. *Minnesota Med.*, 13: 572-577, 1930.

20. Heyman, C. H. Thoughts on the relief of sciatic pain. *J. Bone & Joint Surg.*, 16: 889-894, 1934.

21. Howard, F. J. and Peck, W. S. Clinical and roentgenological study of low back pain with sciatic radiation- roentgenological aspects. *Am. J. Roentgenol.*, 37: 461-466, 1937.

22. Johnson, R. W., Jr. Posterior luxation of the lumbosacral joint. *J. Bone & Joint Surg.*, 16: 867-876, 1933.

23. Kendell, A. G. Low back pain and sciatica—its etiology, diagnosis, and treatment. *Surg., Gynec. & Obst.*, 65: 195-216, 1937.

24. Keuros, J. G. Low back pain. *Rhode Island M. J.*, 19: 131-133, 1936.

25. Lasègue, C. Considérations sur la Sciatique. *Arch. gén. de méd.*, 2: 558-580, 1864.

26. Mitchell, G. A. G. Lumbosacral strain. *Lancet*, 1: 75-80, 1936.

27. Naffziger, H. C., Inman, V. and Saunders, J. B. C. B. Lesions of the intervertebral disc and ligamenta flava. *Surg., Gynec. & Obst.*, 66: 288-299, 1938.

28. Ober, F. R. The role of the iliotibial band and fascia lata as a factor in the causation of low back disabilities and sciatica. *J. Bone & Joint Surg.*, 18: 105-110, 1936.

29. Pitkin, G. and Pheasant, H. C. Sacrarthrogenetic telalgia: I. A study of referred pain. *J. Bone & Joint Surg.*, 18: 111-133, 1936.

30. Putti, V. Lady Jones lecture on new conceptions in the pathogenesis of sciatic pain. *Lancet*, 2: 53-60, 1927.

31. Rogers, M. H. and Clawes, E. N. The adolescent sacroiliac syndrome. *J. Bone & Joint Surg.*, 17: 759-768, 1935.

32. Smith, A. De F. Differential diagnosis of conditions causing pain in the lower back. *M. Clin. North America*, 2: 1771-1776, 1937.

33. Smith-Petersen, M. N. Clinical diagnosis of common sacroiliac conditions. *Am. J. Roentgenol.*, 12: 546-550, 1924.

34. Steindler, A. Low back pain—an anatomical and clinical study. *J. Iowa M. Soc.*, 15: 473-479, 1925.

35. Von Lackum, H. L. The lumbosacral region: an anatomic study and some clinical observations. *J. A. M. A.*, 82: 1109-1114, 1924.

36. Williams, P. C. Reduced lumbosacral joint space—its relation to sciatic irritation. *J. A. M. A.*, 99: 1677-1682, 1932.

37. Willis, T. A. Low back pain—the anatomical structure of the lumbar region—including variations. *J. Bone & Joint Surg.*, 19: 745-748, 1937.

MALIGNANT SYNOVIOMA OF THE KNEE JOINT*

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TUMORS arising inside of a joint or from joint structures other than bone are rare. Steindler[8] lists the following tumors of joints: chondroma and chondrosarcoma, cartilage cysts, giant cell tumors, lipoma, fibroma and xanthoma. He further states, "Capsular hemangioma is seen in the capsule of the knee joint." von Rosen[9] also lists angiomas; and Firaud, Salmon, and Paillos[4] cite a case of myeloplax tumor of the synovial membrane of the knee. They state, "These neoplasias are not in the habit of manifesting themselves as hemarthrosis, *which is rather the finding with angiomas and malignant tumors.*" Malignant tumors of soft tissues are listed by Steindler as follows: Fibrosarcoma from fascial sheaths, fibrosarcoma from tendon sheaths, intermuscular myxoliposarcoma, synovial sarcoma, muscle sarcoma and malignant neurogenic tumors. "Synovial sarcomas are observed. The outstanding symptoms are pain, tender mass, swelling of the joint. They are radio resistant."

Knox,[5] writing in the *American Journal of Cancer* in 1936 says: "Among the malignant tumors of the extremities a relatively small group take their origin from the specialized connective tissue cells which form the synovial linings as well as from the deeper layers of fibrocytes in the walls of bursae, tendon sheaths, and the articular surfaces of the joints."

From the above paragraphs it is noted that synoviomas are not only rare, but also that they are resistant to x-ray therapy. They occur in tendon sheaths and bursae, also in joints. Recurrence after removal is most likely. Amputation is probably the treatment of choice provided metastasis has not already occurred. "Adenopathy almost never occurs."[2] No patient with a synovioma is known to have lived over ten years.[6]

One of the first cases of primary synovial tumor is said to have been reported by Langenbeck in 1865.[2] "In 1931 Razemon and Bizard reviewed the literature for all primary tumors of the articulations and found 74 cases. . . . There are eight well defined cases included in this report that are probably of synovial origin; of these, six were in the knee."[2] In 1927, Smith added three cases and introduced the term, synovioma.[2]

In 1935, Hodgson and Bishop,[6] of Atlanta, reported a case of malignant synovioma of the knee joint. Metastases occurred into the inguinal nodes. X-ray radiation did not help. The patient died seven months later. It is noted, however, that the diagnosis was made from a lymph-node and that the joint was not opened. Aspiration of the knee was done, however. Once straw-colored fluid was obtained but two days later 150 cc. of bloody fluid was found. There was a history of injury in this case to the knee joint about one year previously. The roentgenogram was said to show no evidence of any pathological condition of the bone. It does not mention whether or not there were soft tissue changes in the film. The symptoms were pain and swelling.

In 1936, Knox[5] stated that twenty-two cases of synovial sarcoma had been reported. Of these, nine occurred in the knee joint and three involved tissues lateral and posterior to the knee joint. The chief symptoms were pain and swelling of the joint. These tumors were given pathological diagnoses as follows: myxosarcoma, fuso-globo-cellulaire, villous angiofibroma, perithelioma, synovial sarco-endothelioma, and

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recently the term synovioma has been used. Berger,[1] writing on synovial sarcoma, calls these tumors reticulo-endothelio sar-

Fig. 1. Mrs. V. B., age thirty-five. Lateral roentgenogram of left knee showing soft tissue mass anterior to the lower end of the femur beneath quadriceps tendon. (We believe this synovioma could have been more clearly outlined and an earlier diagnosis made if air had been injected into the joint cavity prior to x-ray examination.)

comas. Histologically, he says they are reticulohistiocyto sarcomas containing a rich network of reticulo fibrils. He prefers terms similar to fibroma and fibrosarcoma and therefore suggests the term, synovialoma, for the innocent group and synovialo sarcoma for those that are malignant. The case we are presenting has been called by Dr. McBride, pathologist at Butterworth Hospital, and by Dr. Weller at University of Michigan, synovial endothelial sarcoma. Smith and Gault[6] state that the synovioma is a specific tumor arising from the serosal cells lining the joint cavities and the bursae. "In general, they may be differentiated from carcinomata by their relatively large, ovoid nuclei and the absence of the typical epithelial nucleoli. . . . Excision has been accomplished successfully in a limited

number of cases. More often, particularly in those tumors arising from the joints where complete excision of the membrane of origin is technically next to impossible, recurrence has been prone to take place. Ultimately these tumors undergo malignant change and pulmonary metastasis is liable to be the end state in the clinical picture. With radical surgery, a high percentage of recovery should result. With irradiation, little or nothing may be expected other than a very transitory regression in the size of the tumor."

In 1937, Coley and Pierson[2] reported fifteen cases of synovioma from the Memorial Hospital and the Hospital of Ruptured and Crippled in New York. Five of their cases occurred in the knee joint and one in the popliteal space. While it is thought that trauma is a causative factor, since about two-thirds of these cases have occurred in males, these men say that Stewart mentions the possibility that inflammatory changes in chronic synovitis might be held accountable for the neoplastic development of some of these tumors. They also mention that Wagner has called attention to the fact that if films are made for soft tissue detail, the presence of the tumor may be revealed. Both of these statements seem to be true in our case. Arthrography and arthroscopy are suggested by Giraud et al.[4] as possible aids in making a diagnosis. X-ray following air injection would have helped us establish a diagnosis, we believe, at the time of the first examination of our patient.

In 1938, a synovioma in the back of the knee was reported by Mallory in Boston. The patient had had pain in the knee for about seven years. The mass had been excised but a lump returned in the scar. Fifteen x-ray treatments did no good. Amputation was done because the pathologist said it approached a sarcomatous process. One other case, reported by von Rosen,[9] was a malignant synovioma of the knee in a man thirty-nine years of age. The patient had had symptoms for

four years. Metastases occurred late into the lymph glands, liver and lungs. Von Rosen advises early amputation to avoid local recurrences. This appears to bring the number of reported cases of synovioma in and about the knee to fifteen in the joint and five lateral and posterior to the knee.

CASE REPORT

Mrs. V. B., age thirty-five, first noticed an uncomfortable feeling in the left knee about three years before. Two years ago, following an acute attack of sinusitis, she had a gradual onset of pain in the left knee. One morning when she awakened the knee was quite distended. There was no history of injury. In September, 1938, she was seen by a medical doctor. Roentgenograms were made and said to be negative. The patient states that aspiration was not done and that she was told to rest the leg and bake it. In November, 1939, after numerous bakings, rest and walking with crutches, there was no improvement. Swelling and pain in the knee had continued. The skin over the knee was mottled from frequent bakings. The patient stated that at times the knee was more swollen and that after baking, it always seemed larger to her and there was not much relief, if any, from the pain. X-ray films were negative for pathological condition of the bone but they showed soft tissue swelling. About 200 cc. of bloody fluid was aspirated from the knee and a questionable diagnosis of angioma of the knee was made. The leg was immobilized in a cast which the patient wore for one month. Following this, there was slight improvement in the knee and exercises were begun gradually.

In February, 1940, the patient returned. Pain and swelling had recurred. At this time there was no fluid superior to the patella, but instead one could feel a soft tissue mass. A roentgenogram confirmed these findings showing the mass under the quadriceps tendon. When the two films were compared, it was believed that this soft tissue mass could also be detected in the November film. Operation was advised and was done February 14. A mass about the size of one-half an orange was found beneath the quadriceps tendon. It was partially incapsulated. There was no induration around it. Degeneration was occurring. When the knee joint was opened, bloody fluid escaped.

The mass extended laterally and posteriorly involving the joint capsule. The synovia in the knee joint proper, was completely degenerated and necrotic. The bleeding points and remaining visible tags of the tumor were electrically coagulated. Rubber drains were inserted on each side of the joint because some hemorrhage was expected. This was very slight, however, and the drainage tubes were removed at the end of forty-eight hours. The patient made an uneventful recovery and was discharged on February 21. The following is a report of the pathologist, Dr. McBride:

"*Gross:* Tissue consists of multiple pieces of tissue removed from the subquadricipital bursa and measures 7 by 7 by 3 cm. The tissue is brownish in color and in some places it appears to be necrotic.

"*Microscopic:* Tissue removed from the subquadricipital area (section a) shows an infiltration of multiple dark staining irregular shaped cells. There are a few giant cells, both of the foreign body type and tumor type. Mitotic figures are few. Section from the joint cavity (section b) is made up of a similar type cell except that they are more closely packed. I believe this is a synovioma and that radical amputation is necessary."

Prepared sections were sent to Ann Arbor for confirmation: "A proliferating and infiltrating synovioma (synovial endothelial sarcoma). In my opinion it is improbable that this has already produced metastases, but it is essential that this neoplasm be completely removed and it would seem probable that this could not be secured without amputation."

Amputation was done on April 4, 1940. The tumor was found in the joint posteriorly also and extended superiorly into the muscles. In November, 1941, the patient was still well and there was no evidence of metastases.

SUMMARY

A brief history of synoviomas in the knee joint has been given. These tumors are rare. A case of malignant synovioma (synovial endothelial sarcoma) of the knee joint is here presented.

Symptoms are chiefly pain and swelling. Trauma is said to be a causative factor in many cases. In this case "chronic synovitis might be held accountable for the neoplastic development." Adenopathy is rare.

The tumor is radio resistant. Metastases occur late to the lymph glands, liver and lungs. In this case aspiration, palpation, and roentgenograms showing soft tissue detail, helped to establish the diagnosis of tumor within the joint. Pneumographic examination is suggested as an aid to diagnosis when bloody fluid is aspirated from a joint in which there is no history of recent trauma.

Recurrence is most likely in all cases. Early diagnosis is essential. If malignant changes are found, amputation is the treatment of choice.

REFERENCES

1. BERGER, LOUIS. Synovial sarcomas in serous bursae. *Am. J. Cancer*, 34: 501, 1938.
2. COLEY, B. L. and PIERSON, J. C. Synovioma—report of 15 cases with review of literature. *Surgery*, 1: 113–24, 1937.
3. HODGSON, F. G. and BISHOP, E. L. Malignant synovioma of the knee joint. *J. Bone & Joint Surg.*, 17: 184, 1935.
4. GIRAUD, SALMON and PAILLOS. Tumeur à myeloplaxes de la synoviale du genou. *Ann. d'anat. path.*, 16: 548–555, 1939.
5. KNOX, L. C. Synovial sarcoma. *Am. J. Cancer*, 28: 461, 1936.
6. MALLORY, T. B. Synovioma of knee, case records of Mass. General Hospital. *New England M. J.*, 219: 204, 1938.
7. SMITH, L. W. and GAULT, E. S. Essentials of Pathology. P. 282. New York, 1938. D. Appleton-Century Co. Inc.
8. STEINDLER, ARTHUR. Orthopedic Operations. Pp. 713–730. Springfield, Illinois, 1940. C. C. Thomas.
9. VON ROSEN, SOPHUS. Ein Fall von synovialem Sarkoendotheliom des Kniegelenks. *Acta orthop. Scandinar.*, 8: 191–207, 1937.

An x-ray of a fracture or of a part containing a suspected fracture should always be made during some period of its treatment. . . . However, a patient should not be subjected to painful handling or shifting, unsplinted, just to get an x-ray for record only.
From—"A Manual of the Treatment of Fractures"—by John A. Caldwell (Charles C. Thomas).

THE USE OF PENTOTHAL SODIUM FOR THE INDUCTION OF ANESTHESIA IN THYROTOXICOSIS*

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AS increasing experience with intravenous pentothal sodium anesthesia has forced it into the group of recognized and desirable anesthetic agents, attention has been called in a few reports to the desirable qualities which adapt this drug especially as a basal anesthetic in the toxic hyperthyroid patient. In a group of sixty-six patients, Carraway[1] employed intravenous pentothal sodium for room induction of anesthesia prior to thyroidectomy, continuing the same anesthetic agent after removal of the patient to the operating room. Ruth, Tovell, Milligan, and Charleroy[2] used a similar method of induction of anesthesia in preparation for ten thyroidectomies, substituting inhalation anesthesia after reaching the place of operation. Murphy[3] reported a case in which a like procedure was carried out.

Every surgeon who has dealt with hyperthyroidism has had the experience of scheduling for operation a patient who appeared well prepared for thyroidectomy only to find it necessary to cancel the procedure because of the state of excitation in which the patient reached the operating room. It is in these individuals particularly that basal anesthesia is of greatest importance. Whereas, many basal anesthetic agents are available, few can be administered without the patient becoming suspicious of the procedure and surmising that operation is contemplated. Even

avertin given rectally is likely to arouse suspicions in the patient's mind. On the other hand, because practically every patient with hyperthyroidism has had repeated diagnostic venipunctures, this procedure can be done without upsetting the patient or making her suspicious of the maneuver. In our clinic, in which a galactose tolerance test is done routinely in hyperthyroidism and usually repeated to determine the improvement of the patient, venipuncture becomes commonplace. On the day prior to the contemplated thyroidectomy instructions are given to the house staff, in the presence of the patient, to repeat a blood chemical examination on the following morning. On the morning of the operation the house officer, who has previously performed the venipuncture, performs another presumably to obtain a blood sample. After inserting the needle, he introduces the sodium pentothal, putting the patient to sleep before she is aware that it is being done. The induction is rapid, entirely without unpleasant qualities; and it allows the patient who has undergone thyroidectomy to awaken later in her room, oftentimes without immediate comprehension that the long dreaded ordeal has been completed. The surgeon's satisfaction in having the toxic hyperthyroid patient arrive in the operating room in the same state of physiological equilibrium in which he last saw her in her own bed is equal to that

of the patient who has had her thyroid gland "stolen."

In a complete review of the British and American literature we have been unable to find a factual analysis of data accumulated during and following thyroidectomy performed after the use of intravenous sodium pentothal. Although impressions gained by us in the use of this anesthetic method tended to support the generalities contained in the literature, we deemed it wise to undertake a statistical study of the material in our hands in an effort to place this particular use of pentothal sodium upon a more rational basis.

For this purpose, fifty consecutive thyroidectomies performed by the Tulane Surgical Staff at Touro Infirmary were chosen for study. For half of this number anesthesia consisted of intravenous pentothal sodium induction in the patient's room, supplemented by inhalation anesthesia in the operating room; while for the remainder only inhalation anesthesia in the operating room was given. The first group, in which there were twenty-one cases of hyperthyroidism, had an average basal metabolic rate on admission of +27.1. The average basal metabolic rate in the latter group, in which were twenty-three patients with hyperthyroidism, was +32.95 on admission. Table 1 indicates the

division of these cases into groups according to toxicity as indicated by the basal metabolic rate.

Preoperative preparation and postoperative care were essentially the same in both groups except for a necessary variation in preoperative sedation. The patients who had inhalation anesthesia alone were given preoperatively a hypodermic of morphine sulfate gr. 1/4 and atropine sulfate gr. 1/150. Three patients received no other sedative; one received in addition avertin, one scopolamine gr. 1/200 hypodermically, one 6 gr. of sodium amytal, five an average of 3 gr. of nembutal, and fifteen patients received an average of 4½ gr. of seconal each. The barbiturates were given in two doses, one the night before operation, the other the morning of operation. The inhalation anesthesia consisted in each case of either ethylene or cyclopropane or both.

Of the group in which anesthesia was induced by pentothal sodium, one received 3 gr. of seconal preoperatively, nineteen received an average of 1/3 gr. of morphine sulfate hypodermically or intravenously after induction of anesthesia, and four received an average of 1/200 gr. scopolamine hypodermically after induction. One patient received no other anesthetic except .55 Gm. of sodium pentothal intravenously. The other twenty-four patients received an average of .426 Gm. of pentothal supplemented by one or more of the gases, ethylene, cyclopropane or nitrous oxide by inhalation. (Table II.)

Each patient of the group receiving pentothal was told on the day before operation that a "blood test" would be made the following morning, a procedure with which each had become familiar during the preoperative hospital sojourn. The anesthetist prepared the solution of pentothal sodium and stood outside the door of the patient's room while the intern assigned to the case made his expected entry. No patient noticed that instead of withdrawing a specimen of blood, the intern proceeded to inject a near colorless liquid. As soon as the patient

TABLE I

DEGREE OF TOXICITY AS INDICATED BY BASAL METABOLIC RATE ON ADMISSION

Basal Metabolic Rate of Admission	Twenty-five Patients Receiving Inhalation Anesthesia Alone	Twenty-five Patients Receiving Intravenous Pentothal Supplemented by Inhalation Anesthesia
+60 to +100	3	3
+30 to +60	9	10
+10 to +30	3	6
−22 to +10	6	4
Not recorded	4	2
Average basal metabolic rate	+32.95	+27.1

became somnolent, the anesthetist entered the room and took command of the situation. In only one instance in our group did the patient become cognizant of the meaning of this ceremony. This occurred when she was placed in a double room with a roommate for whom thyroidectomy had been done a few days previously. The secret was too good to be kept by the first occupant, and the result was that when the morning of operation arrived for the newcomer, her pulse rate and blood pressure

TABLE II
IMMEDIATE PREOPERATIVE MEDICATION

Sedative	Twenty-five Patients Receiving Inhalation Anesthesia Alone	Twenty-five Patients Receiving Intravenous Pentothal Sodium Supplemented by Inhalation Anesthesia
Morphine sulfate..	$\frac{1}{4}$ gr. given all patients	$\frac{1}{5}$ gr. given nineteen patients
Scopolamine.......	$\frac{1}{200}$ gr. given one patient	$\frac{1}{200}$ gr. given four patients
Avertin..........	Given to one patient	
Sodium amytal....	6 gr. given one patient	
Nembutal.........	3 gr. given five patients	
Seconal..........	4.5 gr. given fifteen patients	3 gr. given one patient

were so advanced that the procedure was postponed. Since this occurrence we have been careful to segregate patients awaiting operation from those already past the ordeal.

For the purpose of demonstrating the difference in the response of patients receiving pentothal from that of those who did not, we have chosen to tabulate average pulse and temperature readings taken at definite intervals preceding, during and in the first three days following operation. These and other interesting comparative data are set forth in the accompanying table. (Table III.)

A study of the foregoing data makes obvious a constant difference between the

TABLE III

	Twenty-five Patients Receiving Inhalation Anesthesia Alone	Twenty-five Patients Receiving Intravenous Pentothal Sodium Supplemented by Inhalation Anesthesia
Pulse recordings		
Average during twenty-four hours preceding operation..	90.1	90.9
Early in course of operation—average.......	114.1	98 8
Midoperation average.......	123.2	122 8
Late during course of operation average..	121.2	113.1
Average during first postoperative day.....	108.4	102.4
Average during second and third postoperative days...	114.4	101.8
Temperature recordings		
Average during twenty-four hours preceding operation..	98.54°F.	98.48°F.
Average during first postoperative day.....	100.00°F.	99.58°F.
Average during second and third postoperative days....	100.47°F.	99 79°F.
Duration of operation—average..	71.0 min.	78.9 min.
Average reaction time following operations......	164 min.	67.97 min.
Postoperative stay in bed—average.	8.04 days	5.95 days
Fatalities.........	One died in crisis third postoperative day	One died eighth postoperative day following cerebral accident

two groups of patients in respect to pulse rates and temperature levels obtained

during and following operation. These differences, while small, are important indicators of the degree and rapidity with which these patients were able to make physiological adjustments following the physical and psychic trauma entailed in thyroidectomy. The factual evidence thus tends to bear out an impression which we had gained through clinical observation to the effect that the patients, who went to operation after room induction of anesthesia by pentothal sodium and without foreknowledge of the event, progressed through a much less stormy postoperative course than did their fellows who endured the excitation of an inhalation anesthetic induction in the operating room.

Further corroborative evidence of the salutory effect of pentothal sodium used according to this method would seem to lie in the shorter period during which it was necessary to confine this group of patients to bed. We do not attempt to draw conclusions from the fact that the one fatality during hyperthyroid crisis occurred in the control series, but record the fact in passing.

One unexpected result of our study was the comparative brevity of the reaction time in the group subjected to pentothal sodium anesthesia. An oft repeated objection to the use of pentothal has been an allegedly prolonged postoperative period of coma. Here, however, in the group receiving the intravenous barbiturate the average reaction time was less than half of that of the control series. We believe that this advantage arises because of the les-

sened requirement of preoperative sedation by those patients receiving pentothal. The large doses of the longer acting barbiturates which it was necessary to give preoperatively to the control group, undoubtedly had the undesirable effect of prolonging the reaction period. On the other hand, the action of pentothal sodium in the dosage employed is so short that its therapeutic action was dissipated before the end of the operative procedures.

SUMMARY

1. In a series of fifty consecutive thyroidectomies, twenty-five patients received anesthetic induction by intravenous pentothal sodium supplemented by one or more of the anesthetic gases by inhalation. The remainder were anesthetized by inhalation anesthesia alone.

2. A statistical study of these patients demonstrates in the group receiving the intravenous barbiturate a constantly lower pulse rate and temperature level during the postoperative period.

3. Unexpectedly, the accumulated data reveal a shorter postoperative reaction time in the group receiving the pentothal sodium.

REFERENCES

1. CARRAWAY, C. N. Pentothal sodium oxygen. *South. Surg.*, 9: 313, 1940.
2. RUTH, HENRY S., TOVELL, RALPH M., MILLIGAN, A. D. and CHARLEROY, D. K. Pentothal sodium, is its growing popularity justified? *J. A. M. A.*, 113: 1864, 1939.
3. MURPHY, O. J. Pentothal sodium anaesthesia. *Brit. M. J.*, 2: 1308, 1936.

DELAYED METASTASES IN CANCER OF THE BREAST*

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INSTANCES of long delayed me-
tastases are interesting because the
reasons for the tardy manifestations
of the metastases are imperfectly under-
stood. In the present study, which has
been confined to carcinoma of the breast,
we have attempted in several ways, to find
some factor which might offer some ex-
planation for the wide differences in time
in the appearance of metastases in several
groups of cases. Our attempts have not
been successful.

The literature dealing with delayed
metastases consists mostly of case reports.
A recent gathering is given by Willis
(1934). He reviews eight papers recording
delayed metastases in cancer of the breast
and adds one case of his own. Among
individual contributions we found Uffre-
duzzi's (1930) to be of special interest. He
records four cases of long latency, in all of
which the relation of primary to secondary
growth is established almost beyond doubt
by careful comparison of histological de-
tails. Three cases are cancer of the breast,
with periods of latency between operation
and metastatic recurrence of eleven, twelve
and sixteen years, respectively.

On surveying our material on breast
cancers, we found twenty-nine cases with
recurrence after apparently successful op-
eration in which we were reasonably cer-
tain as to the relation of the primary to
the secondary growths, and the actual
duration of the period of latency. In seven
cases the recurrence occurred in the scar
or in the regional lymph glands; in eleven
cases there were intrathoracic and in
eleven, skeletal metastases. These cases
have been tabulated below in Table I.

Three cases, that is, more than one-tenth

of all cases, showed metastases appearing
after a quiescence of more than five years.
As a first attempt to determine whether
the cases with long delayed metastases
formed a group by themselves, statistical
methods were used. The population repre-
sented in the foregoing table was classified
according to the interval between oper-
ation and recurrence. If the presence or
absence of one well defined factor would
cause the relative benignity of cancer in
certain cases, we would expect the whole
population to be divided into two distinct
groups. If, on the other hand there were
but gradual and not fundamental differ-
ences between high and low malignancy,
we would expect a simple distribution
containing the long delayed metastases as
extreme cases.

In Figure 1 the data of our material are
entered. The abscissa represents the loga-
rithm of time passed after the operation,[1]
the ordinate the percentage of clinically
healthy individuals within this group (i.e.,
of individuals with latent cancer all of
whom finally presented metastases again).
The points entered into this system of
co-ordinates lie fairly near to a regular
S-shaped curve representing a normal dis-
tribution.[2] The median value is 14.2 months
(the mean is considerably higher, viz.,
27.5 months), the coefficient of variation,
2.2. (Fig. 1.)

It is interesting to compare these find-
ings with those obtained by similar surveys.
Leddy and Desjardins (1935) analyzed a

[1] Here, as in many similar cases, a simpler distri-
bution results from the use of logarithmic instead of the
numerical value of time periods.
[2] A group of patients with fourteen months latency
period had to be distributed proportionately to both
groups.

group of patients with . . . . . metastases appearing after apparently . . . . ful interventions. It is evident the delay between operation and recurrent metastatic new growth is determined . . . .

value being 3 months and the coefficient . . . .

Statistical evaluation shows that there is probably some true difference between Pfahler's and Leddy and Desjardins' material on one side, and ours on the other. The . . . . The probability

the curve (dashed line). There, too, a normal distribution results with a median value of 7 months and a coefficient variation of 2.4. Pfahler's (1932) 933 cases, including principally local and regional recurrences, form a group characterized by the same parameters.

An earlier study of the intervals between operation and first obvious occurrence in 687 cases by Rieffel (1890) yielded much shorter periods of latencies, the median

of drawing at random a sample deviating as much as, or more than, our material from a population with parameters as found in Leddy and Desjardins and Pfahler's observations can be figured out by the λ-test (Neyman and Pearson). This probability is only about $\frac{1}{10}$ of 1 per cent. There exists, therefore, almost certainly a true difference between our group of cases and the others. The difference between the two groups is chiefly due to the eleven

cases with intrathoracic metastases. We do not know why, however, our material differs from that of other students.

All the groups studied show a simple, normal type of distribution. Thus the statistical evaluation did not reveal any evidence of other than quantitative particularities in the cases with long delayed metastases. Thus considered, the patients with long latency like Kl. (more than fifteen years) are not more outstanding than those with extremely short intervals like Di. (less than one month). Both represent extreme values of a normal distribution and, if we go a step further, their presence in a sufficiently large sample is as likely as the grouping of about half the cases in the period between seven and thirty-one months, all these events to be expected in a population characterized by a median value of 14.2 and a coefficient of variation of 2.2. We cannot, however, be certain in drawing such conclusions from the study of the distribution of the population. It is always possible and is not to be excluded by statistical methods that two groups are superimposed in such a way as to suggest a simple distribution.

We tried to approach our problem from another angle by looking for factors correlated with the duration of the latency period.

1. *Age of the Patient at the Time of Operation.* Our whole material was divided into two groups of equal size containing the patients with the shorter and longer periods of latency, respectively. The average age (at the time of operation) of the patients who had recurrences after shorter intervals was fifty-five years; of the patients with longer delay, fifty-two years. There is no appreciable correlation in our experience between the age of the patient and the period elapsing between operation and recurrence.

2. *Presence of Metastases at the Time of Operation.* In seventeen cases out of twenty-nine, the presence of metastases was verified at the operation. The periods of latency in this group varied between one

month and six and one-half years, with an average of 15.6 months. In the other cases recurrences occurred after periods of be-
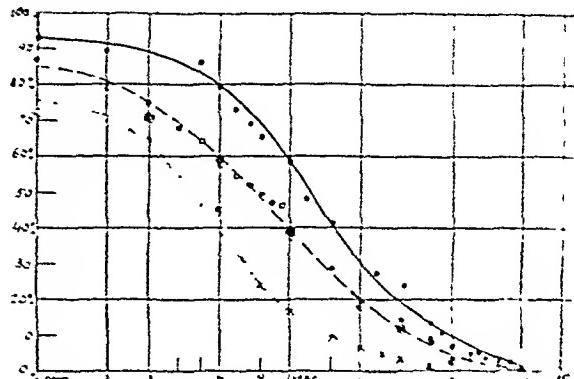
FIG. 1. *Curve:* Distribution of latency periods. *Abscissa:* Logarithm of the time elapsed between operation and first obvious recurrence. *Ordinate:* Percentage of patients with latent cancer. *Full line and circles:* Cases observed in the New Rochelle Hospital. *Dashed line and empty circles:* Patients observed by Pfahler. *Dashed line and double circles:* Patients observed by Leddy and Desjardins. *Pointed line and crosses:* Patients observed by Rieffel. The distribution of latency periods in each of the groups represented here comes very near to the simple, normal distribution. This suggests that each of the groups under consideration is a simple one, not composed by two separate groups of cases with long and short latency periods.

tween eight and 183 months with an average of forty-seven months. Accordingly, a cancer which had already metastasized at the time of operation is less likely to be kept dormant for a considerable length of time than a cancer which was removed previous to recognizable extension.

3. *Preoperative Rate of Growth.* In seven cases it was stated that the tumor grew rapidly before the operation. In these cases metastases occurred after periods of between one and fourteen months with an average of eight months. In ten cases it was stated that the tumor grew slowly before the operation. In these cases metastases occurred after five to forty-eight months with an average of 18.3 months. In twelve cases we had no information as to the preoperative rate of growth. Accordingly, a cancer which develops rapidly is likely to recur sooner than a cancer which grows slowly before the operation.

4. *Localization of Metastases.* In seven cases the recurrence was local or in the regional lymph glands. The periods of

Fig. 2. Roentgenogram of patient K. L. Note thickening of pleura (left), exudate (right) and tumor shadow emerging from the left border of the heart.

latency in these cases were one to forty-eight months, with an average of 13.7 months. In eleven cases skeletal metastases occurred after periods of from one to seventy-eight months with an average of 28.5 months. In eleven cases intrathoracic metastases occurred after six to 183 months with an average of 40.8 months. Local and regional recurrences appear definitely earlier than distant ones. The difference between skeletal and intrathoracic metastases in our material, however, need not be a true one. Whether distant recurrences occur later because the growth needs some time to spread, or because those distant organs are capable of keeping cancer dormant longer, cannot be decided.

5. *Histological Structure.* Twenty of our cases were examined histologically by Doctor James W. Denton.* Fourteen were classified as large duct cancers. In this group periods of latency between one and fifty-four months were observed with a

* Pathologist of the New Rochelle Hospital.

median latency of 8.6 months. Six of the tumors were classified as small duct cancers. In this group the periods of latency
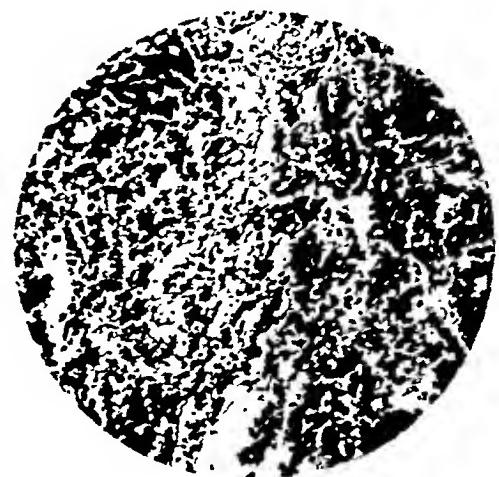
Fig. 3. Microphotograph. Mediastinal node.

varied between one and 183 months, the median latency being 16.7 months. Statistical evaluation by means of the λ-test revealed that this difference of latency periods between the large and small duct tumors need not be a real one and might be entirely due to random sampling.

The analysis of our material has shown that there are definite statistical correlations between periods of latency on one hand, and factors like preoperative rate of growth, extension of the disease at the time of operation, and localization of the recurrence on the other hand. These correlations, however, apply to groups of cases. Individual exceptions from the general rules can be found in considerable quantities.

As a third approach to the problem of delayed metastases, cases recorded in the literature were surveyed with the object of discovering some common traits. We were not able to detect any such factor.

1. *Age.* Advanced age is recorded in several cases (Ganz, Huguenin and Gillet, Pfahler), but several patients were in the forties at the onset of the disease (Ginsburg, Uffreduzzi). Our patient Kle. was only thirty-three years old when first operated upon, and Uffreduzzi's patient Case No. 3 about thirty years old when she first

noticed the tumor. There is no specific age for long delayed metastases.

2. *Extent.* Some patients were operated

recurrence as small duct cancer with occasional attempts to formation of glandular structure; Leddy and Desjardins' two
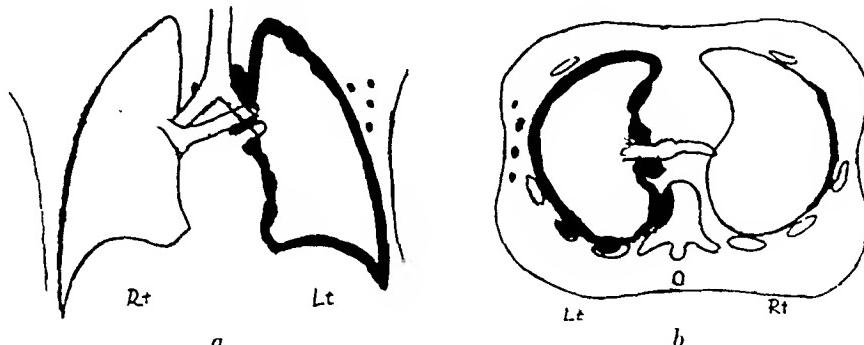
FIG. 4. Half-schematic drawing showing the distribution of cancerous growth in patient K. L. Heavy lines indicate cancerous involvement of the left pleural cavity extending from the mediastinum to the apex, down along the costal surface to the diaphragm and along the diaphragmatic pleural layers to the left half of the pericardium, some ribs and vertebral bodies and mediastinal and axillary nodes. There was a doubtful involvement also of the right pleural cavity indicated by thinner lines. *a,* Frontal section; *b,* transversal section.

upon in the first stage of the disease, but all of Uffreduzzi's three cases had metastases in the axillary lymph-nodes, which were histologically verified, and his Case No. 3 presented lesions in both breasts. Consequently, cancer can be kept latent for a long time even if the disease has previously reached advanced stages.

3. *Localization of Recurrence.* Cases with late local and regional recurrences are recorded (Ganz, Uffreduzzi, Pfahler, Williams (No. 2) Leddy and Desjardins, Barling) as well as skeletal (Ginsburg, Willis, Cameron, Lewin), intrathoracic (Curtis, Graham, Huguenin, Uffreduzzi (No. 1), Williams (No. 1), our case), and intra-abdominal metastases (Uffreduzzi (Nos. 2 and 3), Graham, Bell and Datnar). The power of keeping cancerous growth latent is not restricted to any organ or tissue.

4. *Histological findings* are difficult to compare as exactness of description and nomenclature vary. But it is evident that there are at least several different histological pictures found in cases with long latency. Uffreduzzi's three cases are diagnosed as cystadenoma papilliferum, scirrhus, cystadenoma simplex; our case was reported first as medullary cancer, the

cases are recorded as grade IV cancers. Very dense and hyalinized fibrous tissue is mentioned in Huguenin and Gillet's and in our case.

5. *Rate of Growth.* In two cases (Uffreduzzi's No. 3, Williams' No. 2) it is stated that the tumor was present for ten years before the operation with no period of rapid growth. In most of the cases the preoperative rate of growth is not stated.

Reviewing the results of this survey we concede that it was not possible to separate cases with long delayed metastases from the bulk of the other breast cancer cases by the methods of statistical evaluation of the periods of latency. Correlation of various details, as age, extent, etc., with periods of latency yielded no definite result. We do know that cases in which the tumor had grown slowly and without spread beyond the primary site before the operation are likely to show recurrences (if such occur) later than cases with rapidly growing tumors operated upon in advanced stages. About the same applies to histological findings. We know of many details which characterize the higher or lesser degrees of malignancy in neoplastic disease; but here, as with clinical and anatomical data, the correlation between the detail

observed and the degree of malignancy as measured by the period of latency or the total survival, is also only a statistical one.

rial, some future survey may come to more definite conclusions than were obtained in this study. In the following paragraphs
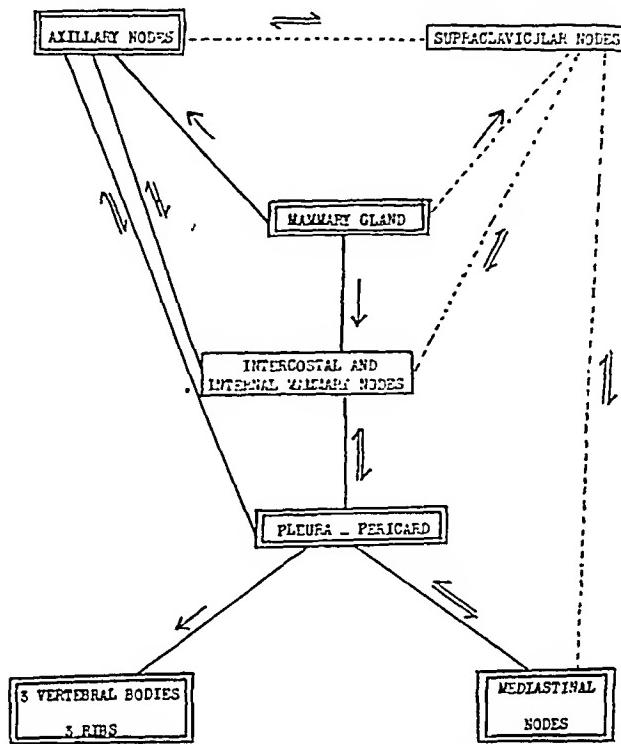
FIG. 5. Schematic drawing showing various possible ways of propagation of cancer in patient K. L. Framing by double outline indicates that cancerous involvement has been demonstrated. Framing by single outline indicates that no special examination at this place was done but that cancerous involvement may be assumed. Plain arrows indicate the direction of extension; double arrows are set where extension was possible in both directions.

Rules concerning the malignancy and the presence or absence of certain known factors apply only to groups of cases. There is no rule to which there do not exist numerous individual exceptions.

Undoubtedly, investigations concerning higher or lower degrees of malignancy in breast cancer have not yet gone very far beyond a survey of the problem. With our present knowledge it seems that the degree of malignancy in a given case of breast cancer depends either on one unknown factor or on the combination of a great variety of factors. Under these circumstances it seems worth while to record case histories of patients with outstandingly high or low degrees of malignancy of breast cancer. On the basis of such mate-

we present the case history of the patient with the longest period of latency we have observed.

CASE REPORT

Miss Kl. was operated upon at the age of thirty-three years, in January 1925, by Dr. A. A. Berg. A radical amputation of the left breast was done. The pathological report was: Medullary carcinoma, axillary nodes not involved.

Patient was apparently in her usual health until April, 1940, at which time she developed pain in the right upper chest accompanied by some difficulty in breathing, mainly on exertion. Physical examination at that time showed no abnormalities in the lungs. The heart was not enlarged, there was a very soft systolic murmur at the apex, rhythm was

normal, blood pressure was 140/90, but pulse was 100. Temperature was normal. Blood count was normal with the exception of 11,250 white cells. Urine examination was negative. Basal metabolism test was a minus 6. X-ray of chest showed some thickening of the left pleura, at apex and base, and a dense shadow with a convex outline emerging from the left border of the heart shadow. A few days later the patient developed severe pain in the right chest, posteriorly, which was diagnosed as dry pleurisy, and she was admitted to the hospital. (Doctor C. C. Guion's service.)

Following admission the patient had low fever for only about ten days. The pulse remained rapid, ranging between 100 and 120. Dyspnea was unchanged and at times there was moderate cyanosis. The physical signs of dry pleurisy continued although radiographic examination at one time showed a small amount of fluid present.

On radiological examination, thickening of the left pleura was visible, especially in the apical region and at the base. A dense shadow with convex outline which could not be explained satisfactorily was visible emerging from the outline of the left ventricle. At autopsy, it was identified as a tumor deposit in the pericardium. On the right side, signs of pleural effusion were noted. (Fig. 2.)

At fluoroscopy, the movements of the left half of the diaphragm were delayed indicating that the inhibition was mechanical in origin and not due to nerve disturbance since there was no paradoxical movement. It was seen at the autopsy examination that the left phrenic nerve was completely ensheathed by neoplastic growth. It could not be found, in fact, within the tumor masses. Under such conditions, we would expect phrenic paralysis. The same, by the way, applies also to the left recurrent nerve. No hoarseness had previously indicated impairment of its function, and at the autopsy examination the nerve could not be found in the tumor masses.

This condition remained stationary until the end of six weeks when the pulse suddenly became weaker and death followed.

The autopsy by Doctor *Denton* revealed more extensive lesions than the clinical findings had indicated. The head and neck were not examined because there was no clinical evidence of involvement of the central nervous system.

The subject was unusually pale but well nourished. The axillary fat on the left side contained several hard, tumorous lymphnodes. There was extensive tumor infiltration of the left half of the mediastinal tissues, the mediastinal pleura and the adjacent pericardial wall being fused in a dense mass. The left vagus and phrenic nerves were undoubtedly involved in these tumorous adhesions but could not be discovered after diligent search. The left pulmonary vessels were narrowed and distorted.

The left parietal pleura was extensively infiltrated and adherent to the lung throughout. The right pleural cavity contained no fluid but the surfaces were covered with recent fibrin deposits.

There was no tumor infiltration of either lung. The right lung was of normal volume. The left was fibrous and of decreased volume, due apparently to tumorous infiltration about the left pulmonary vessels. The heart was normal. Tumorous deposits were found in the left third, fourth and sixth ribs and in the left sides of the bodies of the third, fourth and fifth dorsal vertebrae. These deposits in the bones were not recognizable radiographically.

The abdominal organs showed nothing significant. The organs were somewhat small and atrophic.

Histological examination of the pleurae, diaphragm, pericardium and axillary nodes showed small islets of alveolar carcinoma of mammary type. There was marked fibrous reaction about the islets of tumor cells. (Fig. 3.)

The half schematic drawing—a transverse and a frontal section—shows the extension of the new growth. (Fig. 4.)

The anatomical and histological findings suggest very strongly that the neoplasm was secondary to the previously found cancer of the breast. Both the intrathoracic and the axillary lymph-node localization are typical of metastasis secondary to breast cancer, as is the histological structure of the tumor. We are, therefore, reasonably certain in diagnosing the condition as metastasis from a breast cancer even without being able to compare

the histological structure of primary growth and metastases.

The path of extension cannot be traced with certainty. The scheme (Fig. 5) shows that various ways of spreading could have produced the distribution of cancerous growth as found on autopsy.

The massive and dense thickening of the serous membranes in the left hemithorax undoubtedly was the result of a process of long duration. The involvement of the right pleura—possibly caused by cancerous growth in lymph vessels, which was about two and one-half months old at the time of death—produced only fibrin coating and significant adhesions.

There is some uncertainty as to the final cause of death. There was no direct involvement of any vital organ. The scarcity of symptoms points toward functional heart impairment, the anatomical basis of which might have been the left-sided tumor involvement of the pericardium. Death occurred after the acute stage of the pleurisy and after absorption of the exudate. It is known that not infrequently toxic phenomena appear after absorption of pleural exudate.

The anatomical findings appeared inadequate to explain the patient's death. Whether death was caused by malignant disease alone is known not. It is evident that the tumor behaved for a long time like a benign new growth as evidenced by the absence of symptoms, the unimpaired function of the recurrent and phrenic nerves though surrounded by tumor tissue and the extensive local development of metastases.

SUMMARY

1. Cases of breast cancer with metastasis after radical mastectomy have been tabulated with reference to various details.

2. On statistical evaluation of periods elapsed between operation and recurrence in breast cancer, no evidence of qualitative difference between cases with long and with short latency was found.

3. On surveying various groups of our material it was found that in the average

the shorter periods of latencies occur in cases with rapid preoperative growth, presence of metastasis at time of operation and manifestation of the metastasis in the region of the primary growth. No influence of the age and the histological structure (small duct and large duct cancers) was found.

4. On comparison of cases of breast cancer with delayed metastases compiled from the literature no trait common to all these cases was found.

5. One case with the following features suggesting a very low degree of malignancy was extensively described: (1) A period of more than fifteen years elapsed between operation and manifestation of the recurrence. (2) No clinical symptoms appeared until shortly before death in spite of the evidence that the new growth must have been present for a long time. (3) There was no functional impairment of two nerves in spite of their being surrounded by tumor masses. (4) There was huge local development without spread to distant points.

REFERENCES

BARLING, G. Quoted by Willis. (1910.)

BELL, F. G. and DARNOW, M. M. Quoted by Willis. (1932.)

CAMERON, H. C. Quoted by Willis. (1909.)

GANZ, E. Schicksal der im Roentgeninstitut behandelten Mammakarzinompatienten usw. Strahlenther., 57: 413, 1936.

GINSBURG, S. Osteoplastic skeletal metastases from carcinoma of the breast. Arch. Surg., 11: 219, 1925.

GRAHAM, E. A. Quoted by Willis. (1907.)

HUGUENIN, R. and GILLET, H. Problèmes posés par les phases évolutives d'un cancer du sein. Bull. Ass. Franç. p. l'etude du cancer, 28: 603, 1939.

LEDDY, E. T. and DESJARDINS, A. A. Metastasis of cancer of the breast to the supraclavicular lymph nodes. Am. J. Cancer, 25: 611, 1935.

LEWIN, H. Quoted by Willis. (1928.)

NEYMAN, J. and PEARSON, E. S. On the use and interpretation of certain test of criteria for purposes of statistical inference 1. Biom., 20: 174, 1928.

PFAHLER, G. Radiation therapy in carcinoma of the breast. Am. J. Roentgenol., 27: 497, 1932.

RIEFFEL. Quoted by Williams. (1890.)

ROUVIERE, H. Anatomy of the Human Lymphatic System. Ann Arbor, Michigan, 1938. Edwards Bros. Inc.

UFFREDUZZI, O. Tumori, metastasi neoplastiche e latenza. Cancro, 1: 55, 1930.

WILLIAMS, W. R. The Natural History of Cancer. New York, 1908. W. Wood & Co.

WILLIS, R. A. The Spread of Tumours in the Human Body. London, 1934. Churchill.

HYPOXIA—THE HAZARD OF THE OPERATING ROOM*

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WITH increasing frequency there are appearing in the literature articles, case reports and reviews on hypoxia. More and more often are we informed that everywhere in medical practice we have to face the dangers of a lowered oxygen intake, that we must constantly be alert for signs and symptoms referable to an oxygen deficiency.

Those physicians interested in the pursuit of internal medicine have for many years been aware of the dangers of diminished oxygen in certain pathologic conditions. They have for some time been practicing the early and continuous use of oxygen in high concentrations in pneumonia, congestive failure and meteorism as advocated by Barach,[1] Evans[2] and Fine.[3]

Those of us whose specialties confine us to the operating room have recently seen there a rapid maturing of concepts regarding hypoxia and its dangers. This increased concern for hypoxia reflects an increasing regard for physiological fundamentals on the part of the surgeon.

One of the first reports in which a patient on the operating table was thought to have died at the hands of the anesthetist for want of oxygen was seen[4] only in 1916. Caine,[5] Davies[6] and Downs[7] have each reported cases in which patients under nitrous oxide anesthesia expired either in the operating room or shortly after their return to bed. It is curious that in reporting their cases, these authors, as do many others, lament the fact that so few fatalities with nitrous oxide are written up in the literature. This holds true today even more than at the time these authors write, and it is now generally believed that science would be greatly benefited if all fatalities under nitrous oxide anesthesia were made known.

The case of hypoxia has been championed by Waters[8] who has recently called attention to the incorrectness of the word "anoxia." Etymologically "anoxia" means "without oxygen"—an obviously non-existent condition. The word "anoxia" should, therefore, be replaced with a more correct term—"hypo-oxia" or "hypoxia."

Most of the hypoxia that occurs in the operating room will be the result of nitrous oxide anesthesia. Nitrous oxide is a weak anesthetic agent and will produce nothing but the lightest anesthesia unless metabolic depressant drugs are used as adjuvants. The plane of nitrous oxide anesthesia may be deepened through the diminution of oxygen the patient is permitted to breathe. When the concentration of oxygen in the inspired atmosphere is permitted to drop below 20 per cent, however, the procedure is no longer known as anesthesia. It should properly be termed asphyxia. When more relaxation is demanded than can be obtained by an 80 to 20 per cent nitrous oxide-oxygen mixture, the quantity of nitrous oxide should not be increased at the expense of the oxygen. The anesthetist should change to some more potent agent.

The best exposition of hypoxia that has appeared is Courville's monograph, "Untoward Effects of Nitrous Oxide Anesthesia."[9] Dr. Courville has dealt interestingly and at some length with nitrous oxide and its undesirable effects when inexpertly administered with too little oxygen. His discourse presents everlasting condemnation of the improper use of nitrous oxide and will be a monument in medical literature. He has classified all patients suffering from hypoxia into five groups: (1) Those

dying suddenly on the table; (2) those with delayed exitus; (3) those with prolonged survival periods; (4) those recovering, but with residual cortical damage, and (5) those having transitory mental and emotional changes. He has been so fortunate as to be able to collect detailed case reports on twenty-six patients who had been exposed to hypoxia. The clinical and autopsy findings were seen in each case to follow a rather definite pattern. Courville found that when death was sudden or when it occurred within twenty-four hours the cerebral findings were typical of asphyxia. Insufficient time had elapsed for the development of the more marked signs apparent in those patients with longer survival periods. These evidences of asphyxia were congestion and petechial hemorrhages. It is of interest to note that such changes can be produced at will in experimental animals either by subjecting them to asphyxial mixtures[10] or by artificially stopping the blood supply to the brain. This was done by Weinberger, Gibbon, and Gibbon[11] who ligated the pulmonary artery in cats and found that severe cortical damage occurred if the brain were deprived of oxygen for longer than three minutes and ten seconds.

Varying pathologic pictures will be found in those patients surviving longer than forty hours and who may or may not return to consciousness before death. Here the pathological findings will range from patchy necrosis to widespread degeneration of the cortex and lenticular nuclei. In those instances in which sufficient time has elapsed between the accident and the postmortem examination, there will be seen scarred areas without degeneration.

The symptoms of hypoxia will depend on the degree of oxygen want and its duration. On return to consciousness, the quickly treated patient may present no symptoms at all, or there may be transient mental and emotional changes. When hypoxia has been more severe, there will be prolonged recovery time from the anesthesia and, frequently, convulsions. These are followed by personality changes, hallucinations and progressive mental deterioration. If the hypoxia has been severe, the patient will not regain consciousness. In these cases, deepening coma, hyperthermia and death are to be anticipated, for they are inescapable.

It is by no means true that all the hypoxia seen in the operating room is a result of nitrous oxide anesthesia. Much of it will arise from sources other than the inexpert administration of this agent. It can and frequently does occur with the injudicious use of pain-relieving drugs, nearly all of which reduce the respiratory excursion. Obstruction to a patent airway may result from the sagging jaw, excessive mucus or saliva, vomitus or a relaxed tongue. Deep Trendelenburg position, especially in the obese, sharp angulation of the table in operations on the kidney and use of the gallbladder rest all hinder respiratory movements and aid in the establishment of hypoxia. Persistent laryngospasm will diminish the oxygen available for respiration. None of these factors should be tolerated. Once discovered, it is imperative that the anesthetist take immediate steps to remedy them.

Spinal anesthesia itself may be a potent cause of hypoxia. Seevers and Waters[12] have shown that a "decrease in alveolar as well as arterial and venous blood oxygen occurs" in spinal anesthesia. McClure and his associates[13] have demonstrated a decrease in oxygen saturation of arterial blood of approximately 10 per cent under spinal anesthesia. Such hypoxia is ordinarily attributed to relaxation of the peripheral vascular bed, decreased tonus of the skeletal muscles, diminished respiratory excursion from intercostal paralysis and inactivation of the medullary centers.

The problem of hypoxia in the delivery room is both intricate and interesting. Its consideration is of the utmost importance for here two lives may be ruined by hypoxia. Diminution of oxygen delivered

to the fetus may produce irrevocable damage in its cortex.

The patient's demand for the elimination of pain throughout the first stage of labor must be met. To obtain this analgesia without the production of respiratory depression requires keen judgment and a thorough knowledge of pharmacology and physiology on the part of the anesthetist. During the anesthesia ordinarily accompanying the second stage of labor, an oxygen intake of less than 20 per cent must not be permitted. Frequently it is advisable to use even greater concentrations of oxygen. It is interesting to observe that even in those instances in which cyclopropane was administered with 75 per cent oxygen, the oxygen of the fetal arterial blood ranged from 40 per cent saturation with forceps delivery to 50 per cent in normal deliveries.[14] Both these figures are less than Eastman's[15] for unanesthetized babies. This means that even with a very potent agent like cyclopropane the fetus suffers to some extent from hypoxia. How much more true this is of babies delivered under nitrous oxide anesthesia may be seen from the work of Eastman[16] whose report of five cases showed a fetal arterial oxygen saturation averaging 6.7 per cent. The prevention of hypoxia in the obstetrical patient will require careful and ceaseless observation throughout labor, the thoughtful selection of the proper agent and technic and, finally, complete co-operation between the obstetrician and the anesthetist.

PRACTICAL APPLICATION

From the practical standpoint there are six factors which are of paramount importance in the prevention of hypoxia. Their daily observance will diminish the number of anesthetic accidents and will increase the safety of the surgical patient:

1. The avoidance of the promiscuous use of respiratory depressant drugs. Evidence is ample[13,17,18,19] to show that narcotic drugs (morphine and its derivatives, barbiturates, etc.) tend to decrease the oxidative processes of the cells. This will increase hypoxia. Every patient about to receive a narcotic or sedative must be individualized, and the appropriate dose given. It is inexcusable to order preoperative sedation on a *routine* basis. To order postoperative medication *routinely* is equally indefensible. An individual's response to a respiratory depressant drug can be accurately gauged only by trial and error. The practice of *routinely* ordering repeated doses of narcotics without observing the effects of previous doses is to be thoroughly condemned. The same holds true when avertin is used as a basal anesthetic. Best results are to be obtained when the dose of this drug is reckoned according to the pathology and physiology each patient presents. It should never be ordered on a routine basis.

2. Nitrous oxide should never be given with less than 20 per cent oxygen. If sufficient depth of anesthesia cannot be obtained with this mixture, another agent should be employed. With the numerous agents now at the command of the anesthetist there is no need to subject the patient to hypoxia at any time. In addition to this no anesthesia machine should be used in the modern operating room unless it will deliver accurately calibrated quantities of gases. This is the only way in which the anesthetist can tell the precise percentage of oxygen the patient is receiving.

3. The aim of the competent anesthesist is to disturb the patient's physiology as little as possible. No change in the respiratory rate or volume and no alteration in pulse rate or blood pressure should occur in the well conducted anesthesia. When loss of blood or surgical manipulation occur, these will be reflected in the respiratory or cardiovascular systems. The anesthetist should take appropriate steps to maintain the previous normal levels. Obstruction to respiration should never be tolerated. The *patient should breathe as easily when he is* anesthetized as when conscious. Any increased respiratory effort on the part of the

patient is an indication for an immediate alteration of the anesthetic procedure.

4. It is particularly important that on the return of the anesthetized patient to bed a competent and well instructed person be delegated to remain constantly at the bedside. The patient *must* be protected against aspiration of mucus and vomitus and from asphyxia from a relaxed tongue.

5. It is recommended that patients exhibiting any of the signs of hypoxia in the operating room receive high oxygen concentrations on return to bed. This is *especially true in thyroidectomies.* Schnedorf and his co-workers[20] have found that hyperthyroid patients have a diminished arterial blood oxygen saturation. They demonstrated that the oxygen unsaturation was diminished still more when samples of arterial blood were analyzed one hour postoperatively. Avertin-ethylene-oxygen anesthesia was used in their cases. For varying periods after thyroidectomy they placed their patients in a high oxygen atmosphere. It is their contention that there is a marked endocrine imbalance during this operation to which the body must adjust itself. They felt that breathing was easier, the respiratory rate was lower and that there were fewer changes in the pulse and blood pressure when their patients received oxygen therapy after thyroidectomy.

6. As regards spinal anesthesia, it is recommended that its use should not become a routine matter. The science of anesthesiology has progressed to the point where it can offer the surgeon such a wide variety of agents and technics that to employ one agent and one method routinely for all patients is no longer necessary. Patients for spinal anesthesia should be selected from those whom we classify as good risks. Should there be a severe drop in blood pressure, appropriate steps should immediately be undertaken. One or another of the vasoconstrictor drugs should be given and the patient placed in moderate Trendelenburg position so as to prevent cerebral anemia. Oxygen should be given when there is the slightest evidence of hypoxia. No spinal anesthetic should ever be given unless adequate means of providing oxygen are instantly available. This includes apparatus for endotracheal intubation.

Attention to these details should eliminate hypoxia from the operating room. Where they are not carefully observed, the truth of the words of Haldane will all too quickly become apparent. It was this famous physiologist who said[21] hypoxia "not only stops the machine, but wrecks the machinery."

CONCLUSION

The signs and symptoms of hypoxia have been discussed. Various factors concerned in its production in the operating room have been mentioned. Its deleterious effects have been brought forth. It is recognized that the anesthetist plays a major part in the prevention of hypoxia, and recommendations have accordingly been made for its complete elimination from the modern operating room.

REFERENCES

1. BARACH, A. L. Widening scope of oxygen therapy in treatment of disease. *Cur. Res. Anal. Anes.*, 17: 71, 1932.
2. EVANS, J. H. and DURSHORDWE, C. J. Indications for oxygen therapy in respiratory diseases. *Cur. Res. Anal. Anes.*, 14: 162, 1935.
3. FINE, J., SEARS, J. B. and BANKS, B. M. The effect of oxygen inhalation of gaseous distention of the stomach and small intestine. *Am. J. Dig. Dis. & Nutrit.*, 2: 361, 1935.
4. BALDWIN, J. F. Nitrous oxide-oxygen the most dangerous anesthetic. *Med. Rec.*, 90: 177, 1916.
5. CAINE, A. M. Some unusual complications of nitrous oxide-oxygen anesthesia. *Am. J. Surg.*, 37: 34, 1923.
6. DAVIES, C. W. Death during nitrous oxide anesthesia for proposed extraction of teeth. *Brit. J. Anes.*, 8: 112, 1931.
7. DOWNS, T. McK. The carotid sinus as an etiological factor in sudden anesthetic death. *Ann. Surg.*, 99: 974, 1934.
8. WATERS, R. M. Anoxia—the anesthetist's point of view. *J. A. M. A.*, 115: 1687, 1940.
9. COURVILLE, C. B. Untoward Effects of Nitrous Oxide Anesthesia. Mountain View, California, 1939. Pacific Press.
10. THORNER, M. W. and LEWY, F. H. The effects of repeated anoxia on the brain. *J. A. M. A.*, 115: 1595, 1940.

11. Weinberger, L. M., Gibbon, M. H. and Gibbon, J. H., Jr. Temporary arrest of the circulation to the central nervous system. *Arch. Neuro. Psychiat.*, 43: 615, 1940.

12. Seevers, M. H. and Waters, R. M. Respiratory and circulatory changes during spinal anesthesia. *J. A. M. A.*, 99: 961, 1932.

13. McClure, R. D., Hartman, F. W., Schnedorf, J. G. and Schelling, V. Anoxia—a source of possible complications in surgical anesthesia. *Ann. Surg.*, 110: 835, 1939.

14. Rovenstine, E. A., Adriani, J. and Studdiford, W. E. Gas changes in maternal and fetal blood during cyclopropane obstetric anesthesia. *Calif. West. Med.*, 53: 44, 1940.

15. Eastman, N. J. Asphyxia neonatorum. *Internat. Clin.*, 2: 274, 1936.

16. Eastman, N. J. Fetal blood studies. v. The role of anesthesia in the production of asphyxia neonatorum. *Am. J. Obst. & Gynec.*, 31: 563, 1936.

17. Quastel, J. H. and Wheatley, A. H. M. Narcosis and oxidation of brain. *Proc. Roy. Soc. London*, 112: 60, 1932.

18. Wortis, S. B. Respiratory metabolism of brain tissue: ii. The effects of some drugs on brain oxidation. *Arch. Neuro. Psychiat.*, 33: 1022, 1935.

19. Gross, E. G. and Pierce, I. H. Effect of morphine on the oxygen consumption of brain tissue in the rat. *J. Phar. & Exper. Ther.*, 53: 156, 1935.

20. Schnedorf, J. G., McClure, R. D. and McGraw, A. B. Rationale and use of oxygen in the postoperative treatment of hyperthyroidism. *Surg., Gynec. & Obst.*, 72: 26, 1941.

21. Haldane, J. S. Anoxemia. *Brit. M. J.*, 2: 65, 1919.

Any fracture patient who requires operation should have a program, formulated before the operation is done, and that program should not be disturbed too much, even if complications arise.

From—"Wounds and Fractures"—by H. Winnett Orr (Charles C. Thomas).

MELANOBLASTOMA*

WITH SPECIAL REFERENCE TO METASTATIC DISSEMINATION

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MELANOBLASTOMAS are relatively rare tumors. At The Jewish Hospital, there have been but five in 3,732 autopsies, an incidence of 0.13 per cent. According to Ewing[1] about one-third of all melanoblastomas originate in the choroid, yet the disease occurs in but 0.58 per cent of ophthalmic patients. Davenport[2] reports an incidence of 2 per cent in 1,000 cases of eye disease. The majority of tumors of this type, however, arise in the skin. Melanoblastomas are known to metastasize rather widely, but few cases show as widespread or as unusual metastases as those described below.

CASE REPORTS

Case 1. M. H., a fifty-five year-old white woman, was admitted to The Jewish Hospital of Brooklyn (Services of Dr. M. G. Wasch and Dr. I. Mensher) on January 10, 1936, with a history of failing vision in her right eye and frontal headaches of a few months' duration. Her past history included a myomectomy for uterine leiomyomas and two curettages for menorrhagia associated with endometrial hyperplasia. Examination of her eyes on admission showed diminution in vision of both eyes. A lobulated tumor was found occupying the temporal sector of the fundus of the right eye with some retinal detachment below. Enucleation of the eye was performed. Microscopically, the cornea was well preserved. The anterior portion of the choroid and the entire ciliary body on the temporal side were replaced by a tumor mass composed of large, spindle-shaped and polygonal cells, varying in size and shape. The cytoplasm contained large amounts of dark brown granules. The stroma was scant and also contained pigment scattered throughout. The retina and choroid were well preserved. The diagnosis was melanoblastoma of the eye. No evidence of metastasis was noted at that time. The patient's right orbit was irradiated postoperatively.

In November, 1937, she developed symptoms of hyperthyroidism which subsided after a subtotal thyroidectomy. Grossly, the specimen consisted of two firm portions of thyroid tissue which measured 7 by 6 by 2 cm. and 6.5 by 5.5 by 2 cm. and together weighed 100 Gm. The external surface was pink and lobulated. The capsule was deficient in some places. The cut surfaces showed lobules of light brown tissue mottled and streaked with red, which were separated by delicate gray strands of fibrous tissue. Microscopically, the preparation showed small and large acini filled with pink staining colloid. The lining cells were columnar with distinct borders, abundant pink-staining cytoplasm, and round or oval vesicular nuclei. In some, the cells were heaped up and papillary infoldings were seen. Interacinar cells were numerous. The connective tissue septa were delicate and contained small lymph follicles. No evidence of malignancy was seen. A diagnosis of hyperplasia of the thyroid gland was made.

In October, 1939, a soft, subcutaneous tumor appeared in her left cheek. This was excised. Grossly, the specimen consisted of portions of friable, gray tissue measuring 2.5 by 2 by 0.9 cm. The external surface was irregular and bore papillary projections. The cut surfaces were gray mottled with black. Microscopically, the preparation consisted of various sizes of polygonal, cylindrical and somewhat spindle-shaped cells. The cytoplasmic borders were distinct; the cytoplasm was fairly abundant and granular. The nuclei were round and vesicular and contained prominent nucleoli. Hyperchromatic nuclei and mitotic figures were numerous. Other tumor cells were large, with abundant granular cytoplasm containing

crescent-shaped nuclei which were eccentrically placed. The cells were arranged in small nests or formed cords and strands. Some of the

FIG. 1. Case 1. Metastases in left ventricle.

cells contained golden-brown pigment granules. The stroma was scant and delicate. Scattered within the tumor tissue were islands of fairly well preserved striated muscle fibers. In some areas, the cells appeared to be mounted on delicate stalks. The diagnosis was metastatic melanoblastoma.

Thereafter, her course was steadily downhill. In spite of x-ray therapy, metastatic nodules appeared in the skin. The liver was considerably enlarged. She suffered from increasing weakness, dyspnea and back pain. Roentgenograms of the chest showed circular deposits in the lungs indicative of metastases.

She was admitted to the hospital for the last time on March 18, 1940, in extremis. Her skin was slightly icteric and many cutaneous metastases were noted. Dullness and diminished breath sounds were noted at both lung bases. The liver was enlarged to the umbilicus. Roentgenograms showed metastases in the lungs, skull and pelvic bones. She died on March 21, 1940. Melanin was found in the urine on various occasions. The clinical diagnosis was melanocarcinoma of the choroid with generalized metastases.

The necropsy was performed one and one-half hours postmortem. Only the pertinent findings will be described:

The body was that of a well developed, fairly well nourished, white woman, 150 cm. long, weighing approximately 70 kilograms The

FIG. 2. Case 1. Metastasis in leiomyoma in uterus.

skin was pale. There were many discrete firm, and elastic nodules in the subcutaneous tissue which measured up to 4 cm. in diameter. These were located in the left frontal and right occipital regions, in the right chest wall, in the anterior abdominal wall and in the left thigh. There was a transverse scar in the neck immediately above the clavicles which measured 14 cm. in length. A midline suprapubic scar, 12 cm. in length, was also noted. There was slight pretibial edema and varicosities of both lower extremities. The right eye was missing. The sclera of the left eye was icteric. A firm, discrete movable mass in the left breast, approximately 2.5 cm. in diameter, was felt. The neck and chest were symmetrical and the abdomen protuberant.

The serous cavities contained no excess fluid. There were firm, fibrous adhesions in both pleural cavities. The peritoneum, pleurae, pericardium and diaphragm were studded with gray and black nodules, up to 1.5 cm. in diameter, which showed a tendency to coalesce.

In the thyroid gland a few remnants of thyroid tissue were all that remained of the left lobe. The right lobe weighed 5 Gm. and showed nothing unusual.

The heart weighed 272 Gm. Two gray tumor nodules, measuring up to 1.1 cm. in diameter, were seen in the epicardium on the anterior surface of the right ventricle. There was slight thickening of the mitral valve.

Attached to the endocardial surface of the left ventricle below the aortic orifice were two firm, discrete, gray tumor nodules, each measuring 0.5 by 0.2 cm. (Fig. 1.)

Both lungs were the sites of extensive metastases which measured up to 6 cm. in diameter. Some were gray whereas others were deeply pigmented.

The peritoneum and the mesentery of the small and large intestines were studded with coal black, shiny, tumor deposits measuring up to 0.5 cm. in diameter. Larger nodules, which were gray, red and black on section and measured up to 2.5 cm. in diameter, were also noted in a few places.

The liver was firm, measured 33 by 28 by 11 cm. and weighed 6,250 Gm. Only in the caudate lobe was the architecture preserved. Elsewhere it was completely replaced by tumor tissue which appeared speckled and gray, black and brown in color. The tumor was distributed in sharply demarcated areas which differed in pattern and arrangement.

The gallbladder measured 8 by 2.2 cm. Beneath the mucosa and projecting into the lumen were several, irregularly shaped, coal black tumor masses A single large nodule was seen at the neck of the gallbladder.

The pancreas measured 20.5 by 3 by 2 cm. and weighed 90 Gm. Projecting from the external surface and in the cut surfaces were encapsulated, gray, black and red nodules, measuring up to 1.8 cm. in diameter. The intervening pancreatic tissue showed the usual lobulation.

The right adrenal gland measured 9.5 by 5 by 2.5 cm. and weighed 40 gm. Except for a thin strip of cortex, 0.2 cm. in thickness, the adrenal tissue was completely replaced by tumor. The left adrenal gland measured 5.5 by 4 by 2.5 cm. and weighed 20 Gm. It was similar to the right.

Both kidneys were the seat of metastatic nodules, some of which were large and measured 1.5 cm. in their greatest diameter.

The uterus measured 7 by 5.5 by 3.8 cm. There were two small subserous leiomyomas. Coal black tumor nodules were seen on the peritoneal surface. On opening the uterine cavity, a submucous leiomyoma 3.5 cm. in diameter was seen attached to the wall by a sessile pedicle. The external surface was mottled gray and black in color and glistening. The cut surfaces showed interlacing bundles of gray and white fibers arranged in whorls. Scattered irregularly throughout was deeply pigmented tumor tissue. The Fallopian tubes and ovaries were not remarkable. (Fig. 2.)

The left breast contained a solitary, circumscribed, large tumor mass 2.5 cm. in diameter, which was mottled gray, black and pink in color.

The spleen weighed 245 Gm. and showed no metastases.

The mediastinal, tracheobronchial, portal and peripancreatic lymph-nodes were the seat of tumor deposits.

Small tumor masses were seen in the twelfth thoracic and in the second and third lumbar vertebrae, also in the parietal and frontal bones of the skull. (Fig. 3.)

The dura mater contained flat, deeply pigmented tumor tissue at the site of metastases to the left parietal and right frontal bones. The brain was normal and showed no involvement by tumor tissue.

The right eye was missing. The orbit contained no tumor tissue. The left eye and orbit were normal.

Inasmuch as the histologic structure of the tumors in the various organs was similar, a composite picture is presented. The tumor was composed of solid masses of cylindrical or polyhedral cells, varying in size and shape. The cell outlines were fairly distinct. The cytoplasm was homogeneous and somewhat eosinophilic. The nuclei, for the most part, were round or oval, although some were irregular in shape, many were hyperchromatic. In some the nucleoli were prominent Occasionally, mitotic figures were seen. Within the cell masses were islands of spindle-shaped cells with indistinct borders, scanty cytoplasm and elongated vesicular nuclei. Dark brown pigment granules were seen intracellularly as well as extracellularly in the delicate connective tissue stroma which permeated the tumor and within endothelial-lined spaces.

Anatomic diagnosis: Melanoblastoma in eye (right); absence of eye (right); metastases in skin, breast (left), lymph-nodes, lungs, pleurae, heart, pericardium, diaphragm, peritoneum, liver, gallbladder, pancreas, adrenal glands, kidneys, uterus (in submucous leiomyoma), bones and dura mater.

CASE II. E. V., a thirty-two year-old, white male was admitted to The Jewish Hospital of Brooklyn (service of Dr. L. M. Davidoff) on

July 16, 1940, because of visual disturbances. His past history was irrelevant, but in his family history it was noted that his mother had

but the relative size of the cells was fairly uniform. In other areas, the cells showed an alveolar arrangement. Here again, many of the

FIG. 3. Case 1. Metastasis in left parietal bone.

FIG. 4. Case 11. Metastasis in prostate gland.

died from cancer of the urinary bladder at the age of fifty-five years

In January, 1939, a pigmented mole was removed from the left side of his cheek at another hospital. It had been present all his life, but because it had increased in size rather rapidly during that month, excision was performed. It was reported as a benign pigmented nevus. The specimen was reviewed in the laboratory of The Jewish Hospital and reported as follows:

Microscopically, the stratum corneum was present and not increased in thickness. The stratum granulosum was prominent and consisted of two layers of cells. The hair follicles were dilated and filled with keratin. The rete pegs were prolonged and pointed. The papillae were swollen, edematous, and where not involved in the hyperplastic process, showed a cellular infiltrate, chiefly perivascular in distribution, consisting of small round cells and plasma cells. In one portion of the preparation, at the dermoepidermal junction, there was a very actively proliferating process. On the epidermal side, there was marked thickening of the prickle cell layer (acanthosis) with several concentrically arranged areas of keratinization (pearls). The basal layer merged imperceptibly with the proliferative process immediately beneath it in the corium. The cells involved in the process were large, polyhedral, with vesicular nuclei, many heavily laden with finely granular brown pigment. The corium in this vicinity was densely packed with large, similarly-shaped cells containing large vesicular nuclei with one or two prominent nucleoli. In some areas, the nuclei were hyperchromatic

cells contained pigment. In the adjacent connective tissue there were scattered large mononuclear cells, laden with pigment in a much coarser arrangement than in the cells in the neoplastic process. The diagnosis was junction-type nevus. The presence of an inflammatory infiltrate and the variation in staining effinity of the nuclei indicated some degree of malignancy and invasiveness. The patient subsequently completely forgot about the mole. In May, 1940, he noticed for the first time a "body of slight index of refraction" which seemed to move up and down in the lower half of his visual field about twice a second. This occurred several times in succeeding weeks. In the ten days before his admission to the hospital, this was replaced by bright geometrical figures which moved in the upper outer quadrants of his visual field. Early in July, 1940, he suffered from nausea and vomiting. His handwriting became illegible. Gait became subjectively wide-based. He encountered difficulty in recalling the names of people he knew. He had lost eight pounds in weight since the onset of his illness. Ophthalmological examination by a local oculist revealed a left superior quadrant hemianopsia.

The positive physical findings on admission were: a wide-based, halting gait; anisocoria, the left pupil being larger than the right; diplopia in all directions; slight right facial weakness of the central type; and absent right abdominal reflexes. The multiplicity of findings and the absence of localizing signs suggested metastatic tumor deposits in the brain. At the same time, a small subcutaneous nodule in the right loin was noted. Then upon questioning the patient,

the history of removal of the mole from his cheek, was obtained.

Lumbar puncture revealed an initial pressure

spherical in shape, but in the nests they were polygonal or spindle-shaped. Scattered throughout were foci of small round cell infiltration, and
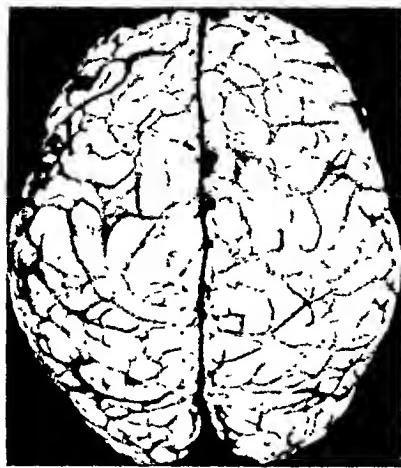
FIG. 5.

FIG. 6.

FIGS. 5 AND 6. Case II. Metastases in brain.

of 204 mm. of water and a final pressure 110 mm. The Ayala index was 5.39, which was within normal limits. Examination of the spinal fluid was negative as were the chemical studies of the blood, the blood count and urinalyses. The cell count showed nine red blood cells per c mm. No melanin was found in the urine. Roentgenograms of the skull, pelvis and chest were negative.

A biopsy of the mass in the right loin was performed. Grossly, the specimen consisted of an elliptical portion of skin, which measured 2 by 0.8 cm. The underlying subcutaneous and adipose tissues were attached. Within the latter, soft and elastic in consistency and not attached to the skin, could be felt a nodule. It measured 0.6 by 0.4 by 0.4 cm. On section, the cut surfaces were somewhat translucent and yellow-brown in color. At one pole a few, small, dark brown areas were noted. Microscopically, in the depths of the subcutis, there was a fairly well circumscribed nodule composed of nests of cells separated from one another by delicate strands of fibrous connective tissue. The majority were spherical although they varied somewhat in size and shape. The cells were very large; the cytoplasm was granular and stained pale violet-blue in some places and amber in others. The nuclei were large, spherical or slightly oval, contained abundant chromatin and large, compact, deeply-staining nucleoli. Karyorrhexis and occasional mitotic figures were seen. Where the cells lay loosely in the tissue, they appeared to be more or less

in a few places, necrosis was seen. Adjacent to the nodule, in some of the lymphatic spaces, were collections of similar tumor cells. The diagnosis was metastatic melanoblastoma.

While in the hospital, the patient became drowsy and weak. Deep x-ray therapy was administered to the brain. He appeared to improve, especially with regard to maintenance of consciousness. He was discharged on September 8, 1940.

Following discharge from the hospital, he vomited considerably, was very weak and complained of severe throbbing headaches. His speech became unintelligible and incontinence of urine appeared. He was readmitted to the hospital on September 18, 1940, in a semi coma. Aphasia was present. The left pupil was fixed. Right facial weakness and ataxia of the hands were noted. A firm, subcutaneous nodule was palpated in the left infraclavicular region. He died on September 27, 1940. The clinical diagnosis was generalized melanoblastomatosis, with particular involvement of the central nervous system.

The necropsy was performed three hours postmortem. Only the pertinent findings will be listed:

The body was that of a well developed, emaciated, white man, 160 cm. long and weighing approximately 50 kilograms. The skin was pale. A scar, 1 cm. in length, was present on the left cheek, and a similar one, 3 cm. in length, in the right loin. There was a sparsity of hair on the scalp. A fairly firm, discrete

tumor nodule, measuring 2 by 1 cm. in diameter, was situated beneath the acromial end of the left clavicle, which on section was

and weighed 1,250 gm. It contained no tumor tissue. The gallbladder and cystic duct were congenitally absent. The remainder of the
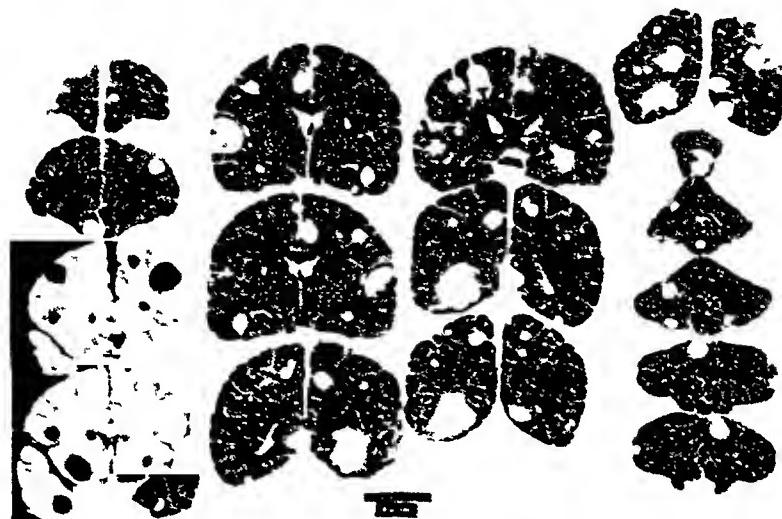
FIG. 7. Case II. Cut surfaces of brain showing widespread metastases.

composed of tumor tissue. Dorsally, over the sacrum, were three decubitus ulcers which measured up to 3 by 2 cm. The neck, chest, abdomen and extremities were otherwise not remarkable.

The serous cavities contained no excess fluid. Within the gastrocolic ligament were two, soft, discrete tumor nodules, which measured 1.5 cm. in diameter. On section, they were composed of gray, black and brown tissue resembling a marble-like pattern.

The thyroid gland measured 5 by 4.5 by 1.5 cm. and weighed 19 Gm. It showed nothing unusual.

The heart weighed 250 Gm., was of the usual size and shape, and not remarkable.

The right lung weighed 560 Gm. and the left 420 Gm. Scattered in the pleura and extending into the underlying parenchyma were several discrete tumor nodules which measured up to 4.5 by 2.5 by 2.5 cm. On section they showed gray, brown and black tissue in a mottled pattern. Zones of necrosis and patchy hemorrhages were seen in places within the tumor tissue. Edema and emphysema were present bilaterally and a focal pneumonia was noted in the right lung.

A punched-out ulcer, 0.8 cm. in diameter, was located 9 cm. below the pylorus. Its margins were steep, the border round and the base clean. The remainder of the gastrointestinal tract was not remarkable.

The liver measured 23 by 20 by 5.5 cm.

biliary tract presented no other anomalies or abnormalities.

The left adrenal gland measured 7 by 4.5 by 4 cm. and weighed 53 Gm. Almost the entire gland, except for a strip of cortex 0.3 cm. in thickness, was replaced by tumor tissue. There were large areas of necrosis and hemorrhage within the tumor deposits. The right adrenal gland measured 6 by 3 by 1 cm., weighed 9 Gm. and was similar to the left.

The right kidney measured 13 by 7 by 3 cm. and weighed 185 Gm. Beneath the capsule and attached to the surface was a dome-shaped, shiny, black nodule, 0.3 cm. in diameter. A cyst was seen on section. The left kidney measured 12 by 6 by 4 cm. and weighed 165 Gm. A gray-brown sharply circumscribed, partially necrotic tumor nodule, 0.8 cm. in diameter, was seen in the cortex. The urinary bladder was not remarkable. The prostate gland was of the usual size, shape and consistency. On section, in the left lobe, a metastatic gray-brown and black tumor, 0.8 cm. in diameter was noted. (Fig 4.)

The spleen was soft, measured 13 by 8 by 3 cm. and weighed 140 Gm. The external surface was slate gray, smooth and glistening. In the cut surfaces, the Malpighian corpuscles were distinct and the fibrous markings delicate. The pulp scraped slightly.

Within the left trapezius muscle was a coal-black, shiny, sharply demarcated metastatic tumor mass, 1.5 cm. in diameter.

The brain weighed 1,766 Gm. The meninges were delicate. The convolutions were broad and flattened while the sulci were shallow. Scattered throughout all portions of the brain, both in the external and cut surfaces, were round, sharply circumscribed, gray, brown and black tumor masses, which in some places showed small areas of hemorrhage and necrosis. They measured up to 4 cm. in diameter. (Figs. 5, 6 and 7.) Although tumor nodules were seen in the brain stem, they were not seen in the spinal cord. Extradurally, however, at the level of the seventh cervical vertebra was a metastasis which measured 1.5 by 1.2 by 1.0 cm. The pituitary gland was not remarkable.

Inasmuch as the various metastases were histologically similar, a composite description is presented: The tumor was composed of nests and whorls of cells lying in a delicate stroma of loosely arranged strands of fibrous connective tissue. These cells, for the most part, were large, and spindle-shaped, with homogeneous, pink-staining cytoplasm extending peripherally in the form of processes which intertwined with those of adjacent cells. The nuclei were round or oval, vesicular, with one or two prominent nucleoli. Although large, the cells showed some variation in their size and shape and in the staining reaction of their nuclei. Some of the latter were deeply staining and mitotic figures and multinucleated giant cells were fairly numerous. Other cells were polyhedral in shape. Many of these, as well as some of the spindle-shaped variety, contained clumps and granules of golden-brown pigment. In some this was very abundant and was seen also within the nucleoplasm. Similar pigment was seen extracellularly. In scattered areas, the tumor tissue was necrotic. Foci of extravasated blood were also seen. In places tumor cells were seen within endothelial lined spaces.

Anatomic diagnosis: Melanoblastomatosis in skin, lymph-nodes, mesentery, pleurae, lungs, adrenal glands, kidneys, prostate gland, muscle and brain; edema and emphysema of lungs; pneumonia, focal (right); splenitis, infectious; emaciation; congenital absence of gallbladder; ulcer in duodenum; decubitus ulcers.

DISCUSSION

Three organs, the heart, uterus and gallbladder, which are rarely the seats of secondary tumor deposits, were sites of metastasis in the first case.

Concerning the heart, it is believed that metastatic tumors in this organ are very rare. Of a total of 36,980 cases of carcinoma, Nicholls[3] noted that metastases to the heart were present in 109 or an incidence of 0.29 per cent. Scott and Garvin,[4] however, reported the heart invaded by metastatic tumor in 10.9 per cent of 1,082 cases of malignancy. Included in the series were ten malignant melanomas, five of which had metastasized to the heart. Stout[5] reported sixteen tumors of the heart in a series of 1,171 autopsies but made no mention of melanotic tumors. Lymburner[6] found that in a series of 8,550 autopsies the heart contained secondary malignant tumors in forty-two cases; of these six were pigmented. Moragues[7] reviewed the literature and found only twenty-three cases of malignant melanoma with cardiac metastasis. To this group, he presented four additional cases of his own. He believed, however, that cardiac metastasis in cases of malignant melanoma were more frequent than the paucity of reported cases led one to think. At The Jewish Hospital among 435 autopsied cases of malignancies of all types exclusive of blood dyscrasias, metastasis to the heart was noted in seventeen, or an incidence of 3.8 per cent.

According to Kaufman[8] and Frank[9] metastatic carcinomas to the uterus are very rare. None of the general textbooks of pathology or the more specialized books relating to malignant disease give any statistics as to their occurrence. In the series of 435 cases of malignancy at the Jewish Hospital, metastasis to the uterus was observed in nine instances, or an incidence of 2 per cent. In no instance was a metastasis to a uterine leiomyoma present. When present the metastases were due to direct invasion from ovarian carcinomas (four cases) or arose from distant organs via the blood stream.

Secondary tumors in the gallbladder, according to Kaufman[10] are similarly ex-

tremely rare but he recalled having seen two cases of pigmented sarcomas with metastases to this organ. In the authors' series, the gallbladder was the site of secondary tumor deposits from remote primary neoplasms in twenty-two instances, an incidence of 5.1 per cent. Most frequently they occur by direct extension from neighboring carcinomas of the biliary tract, stomach or pancreas, and less often, from primary tumors in distant organs.

Geschickter and Copeland[11] found bone metastases in only 1.07 per cent of cases of malignant melanoma. The vertebrae and cranium were the sites of secondary melanotic tumors in the second case. In the first case, these and other organs were the sites of tumor metastases which probably were hematogenous in origin. In the second case, the unusual features were the presence of metastases to the prostate gland, the central nervous system, particularly the brain stem, and absence of involvement of the liver.

No other case in the authors' series of 435 malignancies showed evidence of invasion of the prostate gland by tumor tissue from a remote primary tumor. All authorities agree as to the rarity of metastatic neoplasms in this organ.

In the first case there were metastases to the dura mater and cranium, and in the second case, to the brain. In both instances, the metastases may have arisen as a result of extension from the lungs, while in the first case, the possibility of extension from the orbit cannot be ignored. A third possibility is spread from some distant focus via the vertebral venous plexus and thence to the cranial cavity. This view has been advanced recently by Batson[12] to explain particularly those cases in which there is absence of lung involvement.

The failure of the liver to be involved by tumor in the presence of a generalized dissemination of the neoplasm is an unusual feature worthy of note, particularly in melanoblastomas, in which the liver is so often the site of maximum involvement. Coincidentally, in this case no melanin appeared in the urine at any time.

The congenital absence of the gallbladder and cystic duct is likewise of interest because of its rarity. Robertson et al.[13] reviewed the literature and found only ninety-six previously reported cases of this condition, to which they added one of their own. At The Jewish Hospital, there have been three cases of congenital absent gallbladder and cystic duct amongst 3,618 necropsies, an incidence of 0.08 per cent.

SUMMARY

Two cases of melanoblastomatosis with widespread and unusual sites of metastasis are described. The frequency and sites of metastases in melanoblastomatosis are discussed. In the case in which no melanin occurred in the urine, there was no involvement of the liver.

REFERENCES

1. EWING, J. Neoplastic Diseases. 4th ed., p. 961. Philadelphia, 1940. W. B. Saunders Co.
2. DAVENPORT. Some notes on sarcoma of the uveal tract. Brit. J. Ophth., 11: 609, 1927.
3. NICHOLLS, A. F. Secondary carcinoma implanted on the endocardium of right ventricle. Canad. M. A. J., 17: 798, 1927.
4. SCOTT, R. W. and GARVIN, C. F. Tumors of the heart and pericardium. Am. Heart J., 17: 431, 1939.
5. STOUT, A. P. Human Cancer. Philadelphia, 1932. Lea & Febiger.
6. LYMBURNER, R. M. Tumors of the heart: histopathological and clinical study. Canad. M. A. J., 30: 368, 1934.
7. MORAGUES, V. Cardiac metastasis from malignant melanoma. Am. Heart J., 18: 579, 1939.
8. KAUFMANN. Pathology. Vol. 111, p. 1,667. Philadelphia, 1929. P. Blakiston's Son & Co.
9. FRANK, R. T. Gynecological and Obstetrical Pathology. P. 230. New York, 1931. D. Appleton and Co.
10. KAUFMANN. Pathology.8 Vol. 11, p. 1,008.
11. GESCHICKTER, C. F. and COPELAND, M. M. Tumors of bone. Internat. Surg. Digest., 10: 323–343, 1930.
12. BATSON, O. V. The function of the vertebral veins and their role in the spread of metastases. Ann. Surg., 112: 138, 1940.
13. ROBERTSON, H. F., ROBERTSON, W. E. and BOWER, J. O. Congenital absence of the gallbladder. J. A. M. A., 114: 1514, 1940.

CHOLEDOCHOLITHIASIS*

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IN recent years growing attention has been given to the problem of the common duct stone. The frequency of occurrence of these calculi has increased in direct ratio with the number of common ducts adequately explored at the time of primary operation on the gallbladder.

It has been established that common duct stones may be present in a considerable number of patients in whom there was no clinical suspicion of their existence. Even in the acute inflammatory diseases of the gallbladder, looked upon by many as surgical emergencies, calculi will be found in the common duct in a surprising percentage. Simple palpation of the duct has proved uncertain evidence of the presence of stones. It has become recognized that a certain proportion of the unfavorable results following surgery of the gallbladder for both acute and chronic disease may be attributed to common duct calculi overlooked at the time of the primary operation. More thorough examination of the common duct has been found necessary and the accepted indications for exploration of the duct have been widened. For these reasons, therefore, it is of value to consider briefly the problem of choledocholithiasis. Consideration especially of the incidence and symptoms of common duct stone will establish and justify several indications for exploring the common duct at the time of primary operation on the gallbladder.

ACUTE CHOLECYSTITIS

There is a growing group of radical-minded surgeons who demand that acute cholecystitis be considered as an intra-abdominal surgical emergency requiring operation as soon as possible. Several of the adherents of this school of thought[10,23] support their position by the contention that common duct exploration is an operative hazard that is unnecessary in cases of acute cholecystitis. They argue that the very nature of the pathologic process renders the passage of stones from the gallbladder into the common duct unlikely.

In Table I is summarized the operative experience of a group of representative surgeons reporting from various large hospitals and clinics throughout the United States and Canada. It will be seen that, contrary to the contention of the advocates of emergency or early operation for acute cholecystitis, common duct stones are found in approximately one out of every ten patients with acute cholecystitis. In only 30 per cent was the duct explored, yet in one-third of these calculi were recovered. It is quite likely that as more ducts are explored the percentage of positive recovery of stones will be found to increase.

The frequency with which ductal calculi occur in patients with acute cholecystitis offers a serious objection to the routine application of early or emergency operation. It is well known that in some patients the edema and swelling present in the early acute phase of cholecystitis will prevent anything more than a cholecystostomy being done. The same changes will also prevent adequate exploration of the common duct. In some instances, then, secondary operations will be necessary and the mortality of these will have to be added to that of the first operation. In every case the surgeon will have to temper his decision as to the need for emergency

operation by the knowledge that the common duct should be thoroughly examined.

CHRONIC CHOLECYSTITIS

In Table II are tabulated the reported findings of several surgeons working in the larger hospitals and clinics. Their collective experiences may be accepted as a cent or practically one in eight of all patients with chronic cholecystitis may be expected to harbor one or more stones in the common duct. This becomes even more impressive when it is considered that 6.4 per cent of the cases of common duct stones encountered at the Mayo Clinic[17] and 4 per cent of those encountered at the

TABLE I
INCIDENCE OF CHOLEDOCHOLITHIASIS IN ACUTE CHOLECYSTITIS

Author	Place	Year	Total No. of Cases	Ducts Explored		Stones Recovered		
				No.	Per Cent of Cases	No.	Per Cent of Ducts Explored	Per Cent of Cases
Judd and Phillips[1]	Mayo Clinic (1922–1932 Approx.)	1933	508	72	14.1	43	59.7	8.5
Branch and Zollinger[2]	Peter Bent Brigham Hosp. (1914–1934)	1936	229	45	19.6	19	42.2	8.3
Kunath[3]	Univ. of Iowa Hosp. (1925–1935)	1937	90	10	11.1	6	60.0	6.6
Glenn[4]	N. Y. Hosp. (1933–1939)	1939	219	22	10.0	9	40.9	4.1
Graham, R. R.[5]	Toronto Gen. Hosp. (1934–1939)	1939	57	...	.....	6	....	10.5
Koster and Kasman[6]	Crown Heights Hosp. (1928–1937)	1939	341	341	100.0	24	7.0	7.0
Carter, Greene and Twiss.[7]	N. Y. Post-Graduate Hosp. (1920–1937)	1939	574	98	17.0	80	81.6	13.9
Zollinger[8]	Peter Bent Brigham Hosp. (1934–1939)	1940	121	42	34.7	20	47.6	16.5
Fallis and McClure[9]	Henry Ford Hosp.	1940	320	...	.....	20	....	6.2
Pfeiffer and Martin[10]	Lankenau and Abington Hosp. (1935–1940)	1940	70	5	7.1	0	0.0	0.0
Walters, Gray and Priestley[11]	Mayo Clinic (1939)	1940	88	28	31.8	13	46.4	14.7
	Average	....	2,617 (2,240)	663	29.6	240 (214)	32.3	9.2

fairly representative cross-section of the average surgical experience throughout this country.

Only a little over 30 per cent of the ducts were explored at the time of operation on the gallbladder, yet calculi were recovered from almost 40 per cent of those that were explored. Here again, just as in acute cholecystitis, it seems quite likely that as more ducts are explored the percentage of positive recovery of stones will increase.

The reports reviewed indicate that 13 per Lahey Clinic[19] revealed no stones in the gallbladder.

The need to consider the common duct whenever any primary operation is performed for chronic cholecystitis is self-evident from the figures quoted. Even though some 60 per cent of the ducts explored failed to yield any stones, it is necessary to appreciate that many negative explorations must be made in order to accomplish a high percentage of complete removal of ductal stones and a low

percentage of return of symptoms after cholecystectomy.[19]

SYMPTOMS

The classical signs and symptoms traditionally ascribed to common duct stones comprise the triumvirate of jaundice, colic,

this determined by chemical analysis in every instance. On the other hand, the estimate of the frequency of icterus in several of the reports is based in part on its alleged occurrence in the past. Time and again statements on the part of the patient that bouts of jaundice had occurred

TABLE II

INCIDENCE OF CHOLEDOCHOLITHIASIS IN CHRONIC CHOLECYSTITIS

Author	Place	Year	Total No. of Cases	Ducts Explored		Stones Recovered		
				No.	Per Cent of Cases	No.	Per Cent of Ducts Explored	Per Cent of Cases
Judd and Marshall[12]	Mayo Clinic	1931	13.393*			1.768	. .	13.2
Crump[13]	Vienna City Hosp. (1927)	1931	325*	325	100 0	78	24 0	24.0
Cheever[14]	Peter Bent Brigham Hosp. (1913–1935)	1935	426†	158	37 9	70	44 3	16.4
Lahey[15]	Lahey Clinic (1910–1938)	1938	2.177	718	32 9	323	44 9	14.8
Carter, Greene, and Twiss[7]	N. Y. Post-Graduate Hosp. (1920–1937)	1939	3,306	260	7 8	213	81 9	6.4
Koster and Kasman[16].	Crown Heights Hosp. (1928–1937)	1939	1.072	1.072	100 0	93	8 6	8.6
Walters, Gray and Priestley[17]	Mayo Clinic (1938)	1939	930†	174	18 7	78	44 8	8.3
Allen[18]	Mass. Gen. Hosp. (Personal Series 1930–1939)	1940	266	159	59 7	98	61 6	36.8
Allen and Wallace[18]	Mass. Gen. Hosp. (1930–1939)	1940	2.088	775	37 1	344	44 4	10 4
Zollinger[8]	Peter Bent Brigham (1935–1939)	1940	442	167	37 8	78	46 6	17 7
Walters, Gray and Priestley[11]	Mayo Clinic (1939)	1940	939	230	24 5	122	53 0	12 9
	Average		25.364 (11.971)	3.713‡	31 9‡	3.265 (1.497)	38 2‡	12 9

* Necropsies.
† Includes some cases of acute cholecystitis.
‡ Excluding necropsy figures of Crump.

chills and fever. In Table III a representative series of reports on the frequency of these symptoms are tabulated.

Jaundice. It is not made clear but it appears that what is meant by "jaundice" in the various reports is gross clinical jaundice with evident discoloration of the skin, conjunctivae and mucous membranes. Undoubtedly, a greater percentage of patients with common duct stones would prove to have hyperbilirubinemia were

previously have proved unreliable and misleading.

The net result of figures so compiled ought to produce a clinically acceptable balance. It is noteworthy, then, that roughly one out of every four patients with choledocholithiasis will at no time display any jaundice. (Table III.)

In patients with acute cholecystitis the occurrence of jaundice need not necessarily be due to a calculus obstructing

the common duct. It is well to remember that in the acute phase, and for a variable period following subsidence, the edema at the neck of the gallbladder or in the cystic duct resulting from the impaction of a calculus in these areas may be great enough to cause compression of the adjacent bile ducts. Jaundice may develop, therefore, as a result of ductal obstruction from inflammatory compression. As long as

artificially relieved by medication or operation. At no time is it crampy or colicky, although variations in the peak level may occur during a given attack.

The site of the abdominal colic is variable and by no means is it always in the right upper quadrant. Epigastric pain was described in 40 per cent of Cutler and Zollinger's[24] cases of common duct stone. They believe that the incidence of epi-

TABLE III
INCIDENCE OF SYMPTOMS IN CHOLEDOCHOLITHIASIS

Author	Place	Year	Number of Cases	Jaundice		Colic		Chills and Fever	
				No.	Per Cent	No.	Per Cent	No.	Per Cent
Judd and Marshall[12]	Mayo Clinic (to 1931)	1931	1,608	1,181*	73.4	1,293†	80.4	597	37.1
Lahey and Swinton[19]	Lahey Clinic (to 1935)	1935	221	129	61.4§	172	77.8	9	4.1
MacDonald[20]	Los Angeles County Gen. Hosp. and The Toronto Gen. Hosp. (1927–1932)	1935	27	25	92.5	12‡	44.4	15‖	55.5
Carter, Greene and Twiss[2]	N. Y. Post-Graduate Hosp. (1920–1937)	1939	326	277	85.0				
Zollinger and Kevorkian[21]	Peter Bent Brigham Hosp.	1939	75	61*	81.0	68	91.0	25	33.3
Trueman[22]	Mayo Clinic (1936 and 1937)	1940	219	133*	60.7	169	77.2	75	34.2
Average		....	2,476	1,806	73.2	1,714	79.7	721	33.5
Symptoms Absent in		....	.....	......	26.8 (¼)	.....	20.3 (⅕)	....	66.5 (⅔)

* In history or on admission.

† An additional 275 (17.1 per cent) complained of pain in epigastrium, not sufficiently severe to be classed as colic.

‡ An additional 12 (44.4 per cent) complained of dull pain with radiation.

§ Of 210 cases (ten not given).

‖ Of these eight had fever and seven had chills.

clinical signs of inflammation persist, one cannot be certain if any accompanying jaundice is due to inflammatory edema alone or to an obstructing common duct calculus.

Colic. The term, "biliary colic," is a much misused one. Contrary to its connotation, typical biliary colic is not a colic. It is rather a constant, sharp, severe pain which mounts in a steady, continuous, crescendo fashion to reach a peak, where it remains until the causative factors are spontaneously corrected or until it is

gastric pain is higher in the presence of a common duct stone than in any other complication of choledocholithiasis. It is their belief based upon experimental observations,[25,26] that initial and persistent epigastric pain strongly suggests a calculus distending the cystic or common duct.

The different observers do not clearly specify the standards used in classifying pain as true colic. They emphasize, however, that the severity of the pain was one of the main criteria. Although a larger percentage of patients described some type

of abdominal distress, colic was present in only 80 per cent. (Table III.) One out of every five patients with choledocholithiasis, then, will fail to present a history of typical biliary colic.

Chills and Fever. The relative infrequency of these symptoms is striking. (Table III.) The fact that two out of every three patients with choledocholithiasis fail to show any chills or fever attests to how often calculi may be resident in the extrahepatic ducts without causing any associated cholangitis.

Of the many other symptoms attributed to choledocholithiasis and the associated biliary tract disturbance, two are worthy of special mention:

Previous History Suggestive of Biliary Tract Disease. The vast majority of patients proved to have choledocholithiasis present a history of dyspepsia characterized by fullness, belching, gaseousness, distention and flatulence and recurrent bouts of abdominal pain with or without episodes of jaundice. In the experience of some,[16,24] such a history is a feature of practically every case and in its absence the chance of finding a common duct stone is slight.

Vomiting. It has been observed experimentally[25,26] that while distention of the gallbladder does not cause vomiting, distention of the common duct constantly produces spontaneous vomiting. Cutler and Zollinger[24] make a special point of this and, in their opinion, pronounced involuntary vomiting is suggestive evidence of a stone outside the gallbladder within the cystic or the common duct. Such spontaneous, pronounced involuntary vomiting occurred in approximately 90 per cent of their patients with common duct stone.

Indications for Exploration of the Common Duct. The preceding discussion makes it apparent that stones exist in the main bile channels in a surprisingly large percentage of cases of both acute and chronic cholecystitis. Moreover, the classical signs and symptoms ascribed to such stones are frequently absent and there very often will be no clinical evidence of

their presence. In the final analysis, therefore, the presence or absence of stone must be determined by a careful examination of the ducts.

In any compilation of justifiable indications for exploration of the common duct, due attention must be paid to the salient points stressed above. Zollinger[18] has recently offered such a compilation and the indications he lists may be presented without further comment:

CLINICAL HISTORY

1. History or presence of jaundice
2. Cholangitis associated with cholelithiasis
3. Recurrent symptoms after cholecystectomy
4. Frequent attacks of gallstone colic
5. Pronounced involuntary vomiting

FINDINGS AT OPERATION

6. Suspicion of stone by palpation
7. Dilated or thickened common duct
8. Contracted thickened gallbladder
9. Dilated cystic duct
10. Loss of normal appearance of aspirated bile
11. Thickening of head of pancreas
12. Many small stones in gallbladder and cystic duct

There are many surgeons who, while admitting the facts and agreeing to the need for more frequent ductal exploration, warn that widespread application of such exploration will produce an increase in the primary mortality and an increase in the secondary morbidity and mortality from resultant strictures and injuries to the ducts.

Cutler and Zollinger[24] in the six years prior to 1940 had no death following a negative explorationt of he common duct. They are of the opinion, therefore, that the addition of choledochostomy does not increase the general mortality of biliary surgery. Lahey and Swinton[19] are in accord with this opinion. All are agreed, further, that choledochostomy will not add to the operative risk of gallbladder operations provided that the surgeon has had sufficient experience with biliary tract surgery.

The indications for exploring the common duct are so pertinent that any surgeon who undertakes to remove a gallbladder must be capable of performing with equal success any procedure on the biliary ducts.

Even were it true that the addition of choledochostomy to the primary gallbladder operation increased the operative risk, the eventual mortality of secondary operation for stones overlooked would have to be added to the mortality of the primary operation without ductal exploration if a fair comparison is to be made.

Whether or not increased surgical manipulation of the common ducts will result in a multiplication of such complications as stricture, cholangitis, recurrent stone and the like has yet to be fully determined. The results so far in the follow-up periods now available would indicate that there is not much to fear in this respect.[19,16]

CONCLUSIONS

1. The possibility of choledocholithiasis must be considered in every case of gallbladder disease. Approximately one in every ten patients with acute cholecystitis and one in every eight patients with chronic cholecystitis will have a common duct stone or stones.

2. The classical signs and symptoms of choledocholithiasis are frequently absent. In many instances ductal calculi will be found without any clinical evidence to suggest their existence.

3. The indications for exploration of the common duct have been widened. The addition of choledochostomy to the primary gallbladder operation does not add to the risk in the hands of competent surgeons. No one should undertake to operate on the gallbladder who is not capable at the same time of successfully performing operative procedures on the biliary ducts.

REFERENCES

1. Judd, E. S. and Phillips, J. R. Acute cholecystitic disease. Ann. Surg., 98: 771, 1933.
2. Branch, C. D. and Zollinger, R. Acute cholecystitis—conservative treatment. New England J. Med., 214: 1173, 1936.
3. Kunath, C. A. The treatment of acute cholecystic disease. Surg., Gynec. & Obst., 65: 79, 1937.
4. Glenn, F. Acute cholecystitis. Surg., Gynec. & Obst., 69: 431, 1939.
5. Graham, R. R. Acute cholecystitis. Am. J. Surg., 46: 585, 1939.
6. Koster, H. and Kasman, L. P. The surgical treatment of biliary tract disease (a) acute cholecystitis. Am. J. Digest. Dis. & Nutrition, 6: 373, 1939.
7. Carter, R. F., Greene, C. H. and Twiss, J. R. Diagnosis and Management of Diseases of the Biliary Tract. Chap. 32. Philadelphia, 1939. Lea and Febiger.
8. Zollinger, R. The surgical treatment of gallbladder disease. Rev. Gastroenterol., 7: 420, 1940.
9. Fallis, L. S. and McClure, R. D. Acute cholecystitis—a review of 320 cases. Surg., Gynec. & Obst., 70: 1022, 1940.
10. Pfeiffer, D. B. and Martin, A. G. Acute Cholecystitis, F. H. Lahey Birthday Volume. Springfield, Ill., 1940. Charles C. Thomas.
11. Walters, W., Gray, H. K. and Priestley, J. T. Personal communication.
12. Judd, E. S. and Marshall, J. M. Gall stones in the common bile duct. Arch. Surg., 23: 175, 1931.
13. Crump, C. The incidence of gall stones and gallbladder disease. Surg., Gynec. & Obst., 53: 447, 1931.
14. Cheever, D. Methods and results in the surgical treatment of diseases of the biliary passages. New England J. Med., 213: 463, 1935.
15. Lahey, F. H. Common and hepatic duct stones. Am. J. Surg., 40: 209, 1938.
16. Koster, H. and Kasman, L. P. The surgical treatment of biliary tract disease (b) chronic lesions. Am. J. Digest. Dis. & Nutrition, 6: 376, 1939.
17. Walters, W., Gray, H. K. and Priestley, J. T. Report of the surgery of the gallbladder, liver and pancreas for 1937 and 1938. Proc. Staff Meet., Mayo Clin., 14: 773, 1939.
18. Allen, A. W. and Wallace, R. H. The surgical management of stone in the common bile duct. Ann. Surg., 111: 838, 1940.
19. Lahey, F. H. and Swinton, J. Stones in the common and hepatic bile ducts. New England J. Med., 213: 1275, 1935.
20. MacDonald, I. G. The histology of the biliary ducts and its correlation with the symptomatology of common duct stone. Surg., Gynec. & Obst., 60: 775, 1935.
21. Zollinger, R. and Kevorkian, A. Y. Surgical aspects of obstructive jaundice. New England J. Med., 221: 486, 1939.
22. Trueman, K. R. Symptoms of common duct stone: review of 219 cases. Proc. Staff Meet., Mayo Clin., 15: 283, 1940.
23. Lipshutz, B. Acute cholecystitis. Ann. Surg., 101: 902, 1935.
24. Cutler, E. C. and Zollinger, R. Surgery of the gallbladder and extrahepatic bile ducts. Am. J. Surg., 47: 185, 1940.
25. Zollinger, R. Observations following distention of the gallbladder and common duct in man. Proc. Soc. Exper. Biol. & Med., 30: 1260, 1933.
26. Zollinger, R. Significance of pain and vomiting in cholelithiasis. J. A. M. A., 105: 1647, 1935.

ONE HUNDRED ONE CASES OF INFECTIONS OF THE FACE AND NECK FOLLOWING ORAL PATHOLOGY*

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IN proportion to the number of patients treated each day by the numerous dentists in this city, investigation has shown that complications, resulting from dental pathology are few. We have often seen a friend with a swollen face on his way to the dentist and have sympathized with him, not fully realizing the potential dangers of this swelling. We expect him to get well and in most instances he does. However, in certain cases the infection spreads, and it is about these patients that this paper is concerned.

From July 1, 1939, to July 1, 1940, there were admitted to the Plastic Service of Kings County Hospital, 101 cases of infections of the face and neck, whose etiology was directly attributed to dental pathology. This number does not include fractures of the facial bones nor complications.

The following statistics have been reported. Beck,[1] in reporting twenty-four cases of neck infections, found three due to dental pathology: two cases following single extraction, and one case following multiple extractions because of extensive alveolar disease. Boemer[2] found that one-third of all his adult neck infections were due to infections of the lower molar teeth. Alden,[3] in 1936, presented twenty-nine cases of neck infections resulting from dental pathological conditions. Thus you can see the significance of this subject and we cannot overstress the importance of the pathogenesis nor the treatment. In the analysis of the age, we find the extraordinary fact that the greatest number of complications were found in persons between the ages of eleven and thirty years. Since these persons are of the school age and early industrial age, we certainly can foresee the work that prophylactic care can do.

TABLE I

Age	No. of Cases
2 to 5	1
6 to 10	15
11 to 20	27
21 to 30	29
31 to 40	9
41 to 50	10
51 to 60	8
61 to 70	1
71 to 80	1
Total ..	101

With the spread of the pathological condition from the localized area, there was a notable increase of symptoms. These were characterized by pain, swelling, not only of the local area but of the contiguous regions, fever, malaise and often trismus. Frequently, the spread of infection occurred within the first week.

TABLE II

Day	No. of Cases	Day	No. of Cases
1st	0	7th	8
2nd	15	8th	1
3rd	11	9th	12
4th	12	10th	5
5th	12	11th	5
6th	9	12th	3
		13th	8

A number of cases had no surgical interference, while the most serious ones followed extractions. The teeth listed as to the number of times involved were:

Upper teeth	8	7	6	5	4	3	2	1	—	1	2	3	4	5	6	7	8
Times involved	4	1	7	1	4	1	4	10	—12	2	4	2	0	3	2	1	

Lower teeth....	8	7	6	5	4	3	2	1	—	1	2	3	4	5	6	7	8
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Times involved ..	8	8	6	1	1	0	0	0	—	1	1	0	3	11	10	7

The upper central incisors are often involved but usually the infection is localized. Thus it can be seen that the lower molars were involved most frequently, and when one considers how closely they are related to the neck and its structures, a study of the anatomy of the neck is imperative before treatment of dental infection can be managed.

Mosher,[4] in his epic talk in 1929, brought to us the importance of the muscles, fascia, vessels and glands of the neck. In a comprehensive manner his description served to stimulate others. His words, "Pus in the neck calls for the surgeon's best judgment, for his best skill, and often for all his courage. Pus in the neck kills by edema of the larynx, or by the burrowing pus, bursting its bounds, and flooding the larynx and trachea," are as pertinent today as they were in 1929.

How does this pus reach the neck from the teeth, and where does it go, once it gets there? Alden[3] believes that as the tooth is infected and the process spreads there is a suppurative periostitis at the side of the local lesion, spreading downward or backward alongside the mandible and then breaking through the deeper structures. A second cause is the infection starting as a soft tissue cellulitis and carried from there to the contiguous structures, sometimes, even to distant structures by venous circulation or lymph channels. Dorrence[5] states that often suppurative material from a dental root will follow the mandibular canal and find exit at the inferior dental foramen and then pass down the mylohyoid groove between the periosteum and the sublingual tissues. Once the pus finds itself in the natural spaces of the neck, it will collect.

What is meant by the natural spaces of the neck? Barnhill[6] very aptly uses this explanation. Disease of either the cervical muscles or of the cervical fascia is extremely rare, and hence, each owes its surgical importance to other reasons. The muscles serve as land marks, while the fascia is important because:

1. It provides a strong wrapping material, which safely and securely encloses the whole of the neck in one package, but also each individual structure or group of structures in its own separate housing.

2. The intervals between the layers of fascia, which contain more or less connective tissue furnish ideal channels through which nerves, lymphatics and blood vessels run.

3. These same connective tissue-filled intervals also provide pathways along which pus may readily burrow. The degree of ease with which pus finds its way about, in the neck depends upon the amount of connective tissue present.

4. There are several areas in the neck where a large amount of connective tissue is present and the knowledge of these places, enables the surgeon to find the sites of disease without entering danger zones. The connective tissue is so abundant in these places that the finger can easily get into them. These places are; (a) in the floor of the mouth; (b) along the carotid sheath; (c) prevertebral or retropharyngeal space; (d) lateral pharyngeal or pharyngomaxillary space, and (e) at the tip of the mastoid (Bezold's abscess).

In order to understand the mechanism of neck infections and the treatment, we must consider the anatomy of the cervical fascia. The superficial layer of the deep cervical fascia covers and encloses all the structures of the neck from the skull above to the clavicle below. Let us start in the midline posteriorly where the fascia is attached to the spinous processes. It runs anteriorly, and splits to enclose the trapezius muscles, unites again, and then splits to enclose the sternocleidomastoid muscle laterally, reunites and anteriorly splits again to envelop the pretracheal or subhyoid muscles. The fascia then fuses in the midline. Viewing this sheath in a perpendicular line, below it is attached to the acromium, clavicle and the manubrium

sterni, forming the space of Buras' behind the latter. Going up, it attaches to the hyoid bone. Leaving the body of the hyoid

not break outward easily, but will point inward, which, as you will see, means going into the lateral pharyngeal space. From
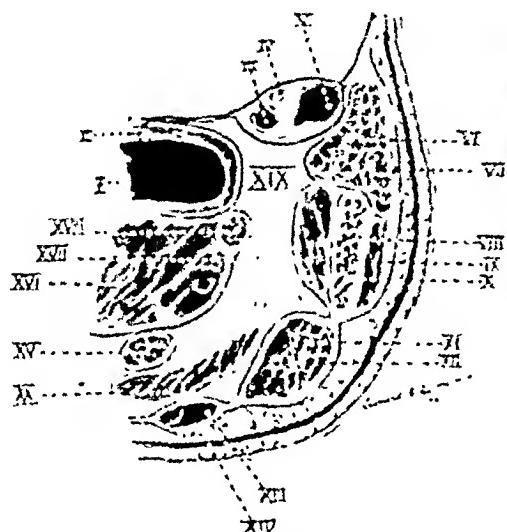
FIG. 1. Oblique anteroposterior view of the face and neck, showing relationships of parapharyngeal space: I, pharynx; II, superior constrictor; III, common carotid; IV, vagus; V, internal jugular vein; VI, parotid gland; VII, fascia external to parotid gland; VIII, masseter muscle; IX, mandible; X, internal pterygoid muscle; XI, submaxillary gland; XII, fascia of submaxillary gland; XIII, anterior belly of digastric muscle; XIV, platysma; XV, geniohyoid muscle; XVI, genioglossus muscle; XVII, hyoglossus muscle; XVIII, stylopharyngeus muscle; XIX, lateral pharyngeal space; XX, mylohyoid muscle.
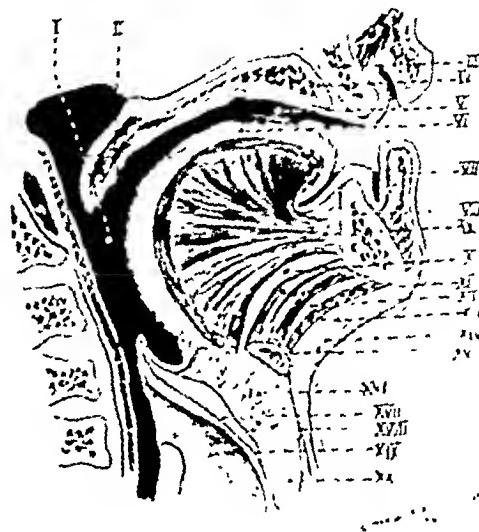
FIG. 2. Vertical midline section through face and neck, showing the spaces in the floor of the mouth: I, pharynx; II, soft palate; III, alveolar process of maxilla; IV, hard palate; V, mouth; VI, mucous membrane of tongue; VII, lower lip; VIII, mandible; IX, genioglossus muscle; X, space between genioglossus and geniohyoid muscles; XI, geniohyoid muscle; XII, space between geniohyoid and mylohyoid muscles; XIII, mylohyoid muscle; XIV, superficial fascia; XV, hyoid bone; XVI, fat; XVII, epiglottis; XVIII, hyothyroid ligament; XIX, vestibule of larynx; XX, thyroid cartilage.

bone, it rises to split and enclose the submaxillary gland, and then attaches itself to the mandible, the inner layer along the mylohyoid ridge and the outer layer to the outer edge of the horizontal ramus or body. This outer layer then runs up and splits to form an envelop for the parotid, in the same manner that the submaxillary gland was enveloped. The outer layer of the parotid fascia now goes up to attach itself to the inferior border of the zygoma. The deep layer of the parotid fascia is thin, while the outer layer is very thick. Mosher[4] states that there are defects in the deep parotid fascia, while Barnhill[6] states that these defects are difficult to demonstrate. This is of great surgical importance, since it means that infections of the parotid will

the zygoma, the fascia will rise to attach itself to the upper nuchal line of the occipital bone and the mastoid process. It covers the temporal muscle and adheres to the temporal ridge.

Having followed the superficial layer of the deep fascia, we will now try to show how deep offshoots of the superficial fascia will make up the fascial planes we have talked about.

First, we must make the statement that the hyoid bone is the most important land mark in the neck. It serves to divide the neck into an upper and lower compartment. The cervical fascia has strong attachments to it and together with the density of the membrane forms a strong

barrier between the floor of the mouth and the infrahyoid region of the neck.

The deep offshoots of the superficial layer of the deep fascia serve to wrap different groups of structures. As the superficial layer splits around the sternocleidomastoid muscle, the deep layer gives off fascia which wraps itself around the great vessels of the neck, thus forming the carotid sheath, or, as Mosher describes it, the Lincoln Highway of the neck. It contains the carotid artery, the internal jugular vein and the vagus nerve. It serves to go up into the skull and down the neck to the chest and forms the main pathway along which pus can travel. Leaving the carotid sheath, the fascia unites again and going deep, forms the prevertebral fascia, which lies in front of the longus colli muscles and the bodies of the cervical vertebrae. Just anterior to the deep offshoot of the carotid sheath fascia, a layer leaves the deep surface of the sternocleidomastoid muscle and runs anterior to the trachea and thyroid, and, being called the pretracheal fascia, serves, by meeting prolongations of the prevertebral fascia, to envelop the visceral structures of the neck, as the esophagus, the thyroid and the trachea, forming the visceral compartment. The pretracheal fascia also goes forward to envelop the omohyoid, sternothyroid and sternohyoid muscles and then meets in the midline.

The fascia thus makes such compartments in the neck that Barlow[7] has named them as four units: (1) Vertebral, (2) visceral, (3) great vessels and (4) vaginal (sternocleidomastoid) (Trapezius).

Between the visceral and the vertebral, there is a rectangular space which runs from the thorax to the skull. It is constricted a bit at the level of the hyoid but it reaches the arch of the aorta.

You will recall that the deep surface of the parotid sheath is thin. From the deep surface of the parotid there is a prolongation that goes deep to attach itself to the styloid and mastoid processes. It is thickened into a ligament running from the

styloid process to the inner surface of the mandible as far down as the angle. This is the stylomandibular fascia which after
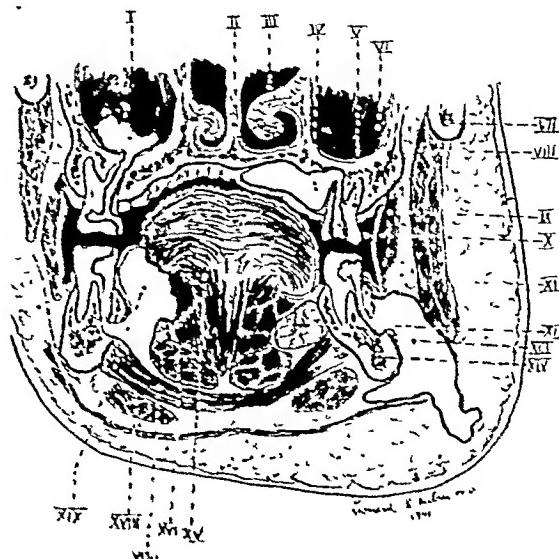
Fig. 3. Diagram showing direction of spread of pus from diseased molars; vertical section through molars: I, pus from tooth ruptured into maxillary sinus; II, nasal septum; III, nasal cavity; IV, pus from tooth ruptured between hard palate and mucous membrane; V, molar tooth; VI, maxillary sinus; VII, zygoma; VIII, masseter muscle; IX, buccinator muscle; X, oral cavity; XI, fat pad of cheek; XII, sublingual gland; XIII, pus ruptured externally into cheek seeping towards mylohyoid; XIV, mandible; XV, genioglossus muscle; XVI, geniohyoid muscle; XVII, mylohyoid muscle; XVIII, anterior belly of digastric muscle; XIX, pus ruptured beneath tongue into sublingual space.

attachment to the mandible, moves out to join the superficial layer of the cervical fascia. In this process, it separates the parotid from the submaxillary gland. This is of great importance, since it will serve as the posterior wall of the lateral pharyngeal space.

You may think that we have digressed from our original discussion of tooth infection but it was necessary to explain the fascial ramifications because they form the spaces into which the pus from the teeth invade.

The submaxillary space must now be considered. It is formed by the splitting of the superficial layer of the cervical fascia and is complete, enclosing the submaxillary gland (which has its own sheath and rarely is infected itself), the facial

artery which enters the gland behind, and then becomes superficial. The gland, turning around the posterior border of the

FIG. 4. Finger inserted through incision toward parapharyngeal space.

mylohyoid muscle juts in between the internal pterygoid and the lateral pharyngeal space making a direct root from the submaxillary space to the lateral pharyngeal space. Infection of the submaxillary space is most common. We believe that this space is infected first and then the pus spreads to other spaces, the most common being the lateral pharyngeal space. Barlow,[7] using the dye injection method, somewhat like Kanavel, showed that injection of the submaxillary space drove the fluid: (1) behind the posterior border of the stylohyoid muscle to the floor of the mouth where it produced a bulge; (2) back between the internal pterygoid and lateral pharyngeal wall or the so-called lateral pharyngeal space, and (3) down and inside of the condensation of the facial vein and the lingual vein from there to the carotid sheath.

A survey must now be made of a most important space known by anyone of the following names, as the lateral pharyngeal space, the parapharyngeal space or the pharyngomaxillary space. Mosher[4] called attention to it in 1929 and attributed most of the etiology to pathological

conditions in the pharynx. We find that it is very commonly infected by suppuration coming from the submaxillary
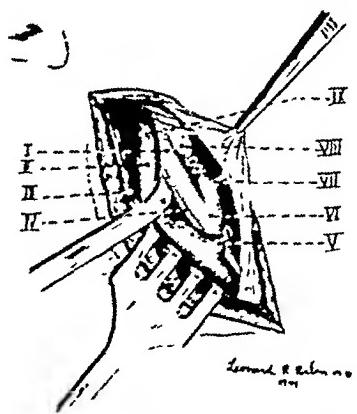
FIG. 5. Tying off the external carotid artery above the superior thyroid artery.

space, secondarily from infections of the lower molars. Alden[3] states that the second and third molars often infect the parapharyngeal space. Ford[8] reports that the lateral pharyngeal space is involved in half of all deep neck infections. Beck[1] reports the tonsils as the cause in 58 per cent of cases. Mosher[4] describes this space as a cone with the base around the jugular foramen of the skull and the apex at the greater corner of the hyoid. The carotid sheath emerges from the apex and for practical purposes continues the cone through the neck and into the chest. It is bounded outside (laterally) by the ramus of the mandible, the parotid, the internal pterygoid muscle and the fascia that covers it. The inner wall is covered by cervical fascia lining the superior constrictor. The anterior wall is limited by the pterygomandibular raphe which is joined by the fascia reflected from the pterygoid muscles and the superior constrictor. Posteriorly, the wall is made up by the styloid process, the stylopharyngeal and the stylohyoid muscles. The stylomandibular fascia and the carotid sheath are behind these; the roof and floor of the cavity are continuous with the carotid sheath. There is much loose areolar tissue around the

sheath, and an abscess breaking into the carotid sheath from the lateral pharyngeal space will travel up and down the neck.

the fascial sheath of the trapezius and also along the course of the intertransverse branches of the vertebral vessels. (2)

FIG. 6. Case of submaxillary and parapharyngeal space infection of molar tooth origin.

FIG. 7. Same as Figure 6 showing large rubber tube sutured in parapharyngeal space.

In surgery into this space, which can be entered easily with a finger, the styloid process is felt on the posterior wall. It must be remembered that ordinarily the space is filled with connective tissue and fat, and is actually in existence only when it is filled with pus. Barlow[7] in his dissections states that the styloid muscle, the stylopharyngeal muscle, and the tough stylopharyngeal aponeurosis, spreading medially and forward from the styloid process and the stylopharyngeal muscle to the lateral pharyngeal wall, act as strong barriers between the carotid sheath and the lateral pharyngeal space. To substantiate this, he injected the space with dyes and was not able to see any spread downward to the carotid sheath.

Barlow,[7] continuing his injection technic on other spaces in the neck, found: (1) *The retrovisceral space*—there was a lateral limit by the fascia covering the trapezius. Below, it traveled to the third thoracic vertebra. Above, it traveled to the skull. Under pressure, it broke laterally into

The parotid space—spreads upward to the temporal space and with pressure spreads to the lateral pharyngeal space and along the fascial and superficial temporal vein. (3) *Subvaginal space*—the space filled rapidly and most completely beneath the sternocleidomastoid muscle and the posterior triangle. The injected fluid did not pass anteriorly into the anterior triangle or under the trapezius nor did it enter any other space. It did outline a space in front of the muscles of the visceral unit that reached from the manubrium to the hyoid. It also filled a space behind the muscles and extended among the viscera, especially the trachea. It did not cross the midline.

Our next subject is the floor of the mouth. An excellent dissection both pathologically and anatomically has been done by Collier and Ygesias.[9] These investigators found that two spaces made up this dangerous area. Under the tongue is a space which lies between it and the geniohyoid muscle. This is the space involved in the so-called Ludwig's angina. Going outward another space exists between

the geniohyoid and the mylohyoid muscle. Actually, there is a space between the skin and the platysma which is involved in

Fig. 8. Parapharyngeal space infection following molar tooth pathology.

erysipelas and superficial abscesses. Also, there is a potential space between the platysma and the mylohyoid muscle. A fifth space, according to Barnhill[6] lies beneath the mucosa and around the sublingual gland.

The space between the geniohyoid and the genioglossus runs from the posterior border of the mandible down to the hyoid bone. If one side is involved, the other side will be too, since there is no partition between them. Barnhill,[6] in his description of the sublingual space says, "Like the other spaces, it is only potential and contains connective tissue. The roof is formed by the mucosa of the mouth, externally, the wall of the pocket is formed by the fascia which envelops the submaxillary gland, and centrally, will be the sublingual gland. The posterior boundary is the fascia, which separates the glands and envelops the muscles of the floor of the mouth. In the anterior part of the space, the lingual nerve will be seen to enter the tongue, also, there will be the ducts of the submaxillary and the sublingual glands, and a little lower and further back the hypoglossal nerve. This

space provides lodgement for infection and separation in the floor of the mouth, commonly known as Ludwig's Angina." He also states that a heavy fascial wall separates the lateral sublingual space from the lateral pharyngeal space. An abscess in the sublingual space will break into the lateral pharyngeal space only if under pressure and neglected. Also, the abscess can readily spread to the opposite side because all muscles and fascia which form the floor of the mouth are bound together only by an abundance of loose connective tissue, which extends from one side to the other.

We have gone into an extensive description of the anatomy of the cervical fascia, because, only in complete understanding of these parts will we be able to perform proper surgical remedies. The spaces mentioned above are most likely where pus is found. It must be remembered, that the pus will follow these spaces and that strong fascial sheaths will delimit the pus, but in neglected cases, erosion of these fascial planes will allow pus to pass from one space to another.

DIAGNOSIS

Localized abscess is a common dental pathological condition. It is only when it begins to spread that we are concerned. Most often, there is a history of toothache, followed by swelling of the region. When spread occurs to any of the spaces, there is associated malaise and fever. The most common spread from the molars is to the submaxillary space which is characterized by marked swelling, anterior to the angle of the jaw and spreading down the neck. Also, there is a moderate temperature and a slight trismus. In most cases when there is a further spread, trismus becomes marked and the temperature will rise to 103°F. or higher. At this point, we can be sure the infection has spread between the submaxillary and the internal pterygoid muscle and has entered the lateral pharyngeal space. In our series we had twenty such cases. If the lateral pharyngeal

space becomes filled with pus, we may have a Horner's syndrome, characterized by dilation of the pupil on that side, due

space, the symptoms would be that of fever, chills, marked swelling over the parotid region, no fluctuation (because of

Fig. 9. An early Ludwig's angina.

Fig. 10. Parotid space infection of dental origin.

to irritation of the sympathetic nerve. The temperature may rise to 105°F. and the patient may become very toxic. Septic temperature rise makes one suspect infected thrombus of the internal jugular vein, and this can be verified by a blood culture. Many authors mention the bulging of the tonsillar region in lateral pharyngeal infection. We can say only that there is such trismus present that we have been unable to visualize this area in order to confirm the bulging.

We have seen five cases that we consider Ludwig's. In all, the pathology was present originally in the molars of the mandible with a submaxillary space infection. Suddenly, there were chills, rise in temperature, swelling of the floor of the mouth and submental region, breathing became difficult and the patient became very toxic. The tongue appeared to be markedly swollen. Rarely was fluctuation felt under the chin, instead, it felt hard and woody, giving it the name woody phlegmon.

Should the infection start in the parotid

the heavy parotid sheath externally) and soon thereafter, trismus may appear. The trismus tells of the involvement of the lateral pharyngeal space. In one of our cases, there was a spread from the parotid space along the fascia to the temporal space. This was characterized by swelling of the temporal region, marked edema of the eyelids, but again, no sign of fluctuation. If the suppuration breaks superficially, it will appear around the outer canthus.

TREATMENT

Let us quote Mosher[1] who said, "Pus in the neck calls for the surgeons' best skill and often for all of his courage. Pus in the neck kills by edema of the larynx, or by burrowing pus bursting its bounds and flooding the larynx and trachea. Cosmetic surgery and life and death surgery do not mix. No small incisions should be made. The deeper the surgeon works, the smaller the operative field."

The patient, upon admission to the hospital is very sick. If active treatment is started, the prognosis is good. In our 101

FIG. 11. Convalescent parapharyngeal space infection. Preliminary tracheotomy had been done.

cases, there were two deaths: one patient had a well developed bronchopneumonia when admitted; the other patient who had been neglected for several days, did not respond to surgery. It must be remembered that the average submaxillary space infection localizes and is often fluctuant. If no fluctuation is present and the temperature remains high, it is time for immediate surgery, since the spread has been inward to the parapharyngeal space. Sulfanilamide is a great adjunct and is given routinely in all severe infections. Hot compresses are placed on the infected side, provided surgery is not immediately indicated. Hot saline mouth gargles are indicated every half hour. With little toxicity, we can wait for fluctuation. When fluctuation occurs, a local incision and drainage into the submaxillary space is performed. This is done by making a skin incision below the inferior margin of the mandible from the angle of the mandible half way anteriorly toward the symphysis. A curved clamp is then inserted to the periosteum of the infected tooth area and

the pus is allowed to escape. A long tube is inserted and then connected with an irrigating apparatus for continuous drainage and irrigation. If we suspect infection of the lateral pharyngeal space, the same incision is made. However, it is imperative that the cervical fascia be incised below the attachment to the mandible. If the fascia is not incised, the finger will not enter the pharyngeal space. In one case, there was such an extensive swelling of the side of the face, that the exact measurement from the skin edge to the cervical fascia was three inches. The point of entry to the parapharyngeal space is between the submaxillary gland and the downward prolongation of the parotid gland. The index finger is the best guide when properly inserted and the mandible can be felt externally to the finger. We have not investigated the lateral pharyngeal space through the tonsillar fossa, always believing that the course of the pathological condition was through the submaxillary area. When the carotid sheath is involved, we use Mosher's T-incision, following along the inferior margin of the mandible and then along the anterior border of the sternocleidomastoid muscle.

In some cases, due to the destructive processes of suppuration in the neck spaces, uncontrolled hemorrhage occurs and prompt ligation of the external carotid is essential. In tying the external carotid for bleeding, the incision is made along the anterior border of the sternocleidomastoid muscle for a distance of three inches. The muscle is reflected posteriorly and the tip of the great horn of the hyoid is felt. Posterior to the tip of the great horn of the hyoid will be found the external carotid artery. Where infection is present in the internal jugular vein the same incision is made. The facial and lingual veins are present about the tip of the hyoid, the facial below and the lingual above. In exposing the internal jugular vein, one must be careful not to injure the superior thyroid artery. The tip of the great horn is the most important landmark in the

neck. It can always be seen and palpated. Of the sixteen important structures of the neck, only the glossopharyngeal nerve, the recurrent laryngeal nerve and the phrenic nerve are not in relation to the great horn of the hyoid bone.

Whenever there is marked difficulty in breathing, the problem of early tracheotomy presents itself. We definitely believe in early tracheotomy in such cases before any surgery is attempted on the neck infection. Previously, we have had some dramatic experiences in cases in which the tracheotomy was not done before the surgical incision and drainage. When the tracheotomy is done early, the surgeon can believe that his patient is safe from a respiratory standpoint and that the drainage can be performed whenever necessary. Occasionally, we hear surgeons state that they always have a tracheotomy set, steriled and handy at the bedside. To us, this appears as wishful thinking. When the respiratory accident happens, every second counts and the resulting drama makes a simple operative procedure appear mediocre.

When Ludwig's is present, we do not wait for fluctuation. Gorden New[11] stresses conservation in woody phlegmon where, he says, pus is never encountered and should never be incised even though it takes weeks to subside. He believes that the barriers set up by nature are of even greater importance than the fascial planes. We differ sharply with him here. From our anatomical studies we have concluded that watchful waiting will leave us a dead patient. We have never incised a Ludwig's through the mouth, although Barnhill mentions it to be one method of approach. A local anesthetic is used on Ludwig's surgery as in other space infections. We usually make our incision run from one submaxillary space to the other submaxillary space through the submental region. The spaces are carefully explored by blunt dissection. We suture tubes into the spaces and later connect them to irrigation cans of hot saline.

Previously, we have made midline incisions, but we now agree with R. Colp[12] that there is no point in doing this.

FIG. 12. Convalescent Ludwig's angina of dental origin. Preliminary tracheotomy was necessary.

When the parotid is infected, we make one or more incisions anterior to the tragus. With a clamp we break into the parotid space, spreading our clamp carefully so as to avoid injury to the facial nerve.

In two cases of temporal space infection, we made our incisions at the level of the top of the external ear, cutting through the temporal fascia to reach the abscess. At times the pus will burrow into the deep temporal space between the temporal muscle and the skull. This pocket must be broken into and a tube deeply placed so as to permit thorough drainage.

Alden[3] states that a great number of his bacteriological studies show the presence of the Vincent's organism and that he routinely gives neo-arsphenamine intravenously (0.4 Gm.) after admission. We have not used this treatment.

CONCLUSION

From July 1, 1939, to July 1, 1940, there were 101 cases admitted to the Plastic Service of Kings County Hospital, with face and neck infections following dental pathological conditions. Of these, forty-one patients recovered under conservative treatment, twenty-three of which were intra-oral spontaneous drainages. Twenty-six patients had internal or intra-

oral incisions. Thirty-four external incisions were necessary, twenty-seven of which showed involvement of the submaxillary space. Twenty of the twenty-seven submaxillary space infections further developed into a definite involvement of the lateral pharyngeal space. Five cases were Ludwig's and each started with a pathological condition in the lower molar teeth. In two of the Ludwig cases, the tooth involved had been extracted two days previously and the following day the socket had been scraped. The symptoms of Ludwig's followed in twenty-four hours. There were two cases of parotid space involvement. Two patients had involvement of the temporal space. There were no retropharyngeal infections in this group.

Of the deaths, we report two cases. One was a fulminating parapharyngeal abscess following tooth extraction and scraping of the socket. This patient was ill for several days before admission and did not respond to surgical treatment. The second case was that of a moron, who was admitted with a submaxillary space infection and a well developed bronchopneumonia.

We offer the following brief outline of the surgical treatment rendered: (a) Careful mouth hygiene (tooth brush, mouth washes), (b) chemotherapy: sulfanilamide, etc., (c) intravenous medication, (d) transfusions, (e) nasal feeding if necessary and practical, (f) incision and drainage promptly done, (g) rubber tube sutured in wound for drainage and postoperative irrigations, (h) tracheotomy done early when indicated, (i) ligation of the external carotid for continued hemorrhage into the spaces, and (j) ligation of the internal jugular vein when involved.

REFERENCES

1. A. L. BECK. Study of 24 cases of neck infections. *Ann. Otol., Rhinol. & Laryngol.*, 42: 741, 1933.
2. L. C. BOEMER. Great vessels in deep infections of the neck. *Arch. Otolaryngol.*, 25–465: 5, 1937.
3. A. M. ALDEN. Neck infections of dental origin. *J. A. D. A.*, 23: 854, 1936.
4. H. P. MOSHER. Submaxillary fossa approach to deep pus in the neck. *Tr. Am. Acad. Opth. & Otolaryngol.*, 20: 36, 1929.
5. G. M. DORRENCE. Acute infections of the soft tissues of the neck. *Surg. Clin. North America*, 17: 1797, 1937.
6. J. F. BARNHILL. Surgical Anatomy of the Head and Neck. Pp. 12, 13, 228. Baltimore, 1937. William Wood & Company.
7. D. J. BARLOW. Surgical anatomy of the neck in relation to septic lesions. Investigation of cervical connective tissue. *J. Anat.*, 70: 548, 1936.
8. H. L. FORD. Deep neck infections, surgical approach. *Illinois M. J.*, 65: 117, 1934.
9. COLLIER and YGLESIAS. Infections of the lip and face. *Surg., Gynec., & Obst.*, 60: 277, 1935.
10. J. BARNHILL. Surgical Anatomy of the Head and Neck. P. 232. Baltimore, 1937. William Wood & Company.
11. GORDEN NEW and JOHN ERICH. Deep infections of the neck. Collective Review. *Internat. Abst. Surg.*, 68: 555, 1939.
12. R. COLP. Treatment of deep infections of submaxillary triangle. *Surg. Clin. North America*, 13: 315, 1933.

DIAGNOSIS AND LOCALIZATION OF INTRA-ABDOMINAL ABSCESSES BY ROENTGENOLOGICAL METHODS*

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THE conventional scout film of the abdomen, taken with the patient lying prone on his back, is of aid in making the diagnosis of an intra-abdominal abscess. If the abscess is large enough, it will be revealed as an area of opacity, with displacement of loops of air-filled bowel. Some of these abscesses contain gas, usually produced by the action of the Bacillus coli organism. However, in the ordinary flat film, this gas is not demonstrated.

We believe, that in abscesses which contain gas, the presence and demonstration of gas-fluid levels in the abscess should be utilized to a greater extent, not only in making the diagnosis but also in helping to determine its relations. By demonstrating the gas-fluid levels, with a horizontal x-ray

and the patient is several different positions, one can usually get an approximate estimate of the size and boundaries of the abscess.

FIG. 1. Scout film of the abdomen revealing nothing abnormal.

FIG. 2. Same patient as in Figure 1, in upright position. Arrow points to fluid level within the appendiceal abscess.

This is of the utmost importance to the surgeon, because in planning the surgical drainage, he usually has a choice of several incisions; and the type of incision which he will use is determined by the anatomic relations of the abscess to the abdominal wall and to the surrounding viscera.

This is well illustrated by an appendiceal abscess. Such an abscess usually lies in the right lower quadrant of the abdomen, and one should determine whether the abscess is lateral or medial to the cecum. If lateral to the cecum, in the lateral pericolic "gutter," it may extend up along the

FIG. 3. Same patient as in Figure 1, with patient in a lateral decubitus position showing huge fluid level within abscess. Note that the abscess extends well above the level of the liver and lateral to it so that it may be considered a subphrenic abscess.

FIG. 4. Scout film of abdomen in a patient with a subphrenic and an appendiceal abscess. This film does not reveal anything except distended loops of intestine.

ascending colon. (Case 1, Figs. 1, 2 and 3.) Here the abscess is in contact with the lateral abdominal wall and may be ap-

such a case exact localization of the abscess is invaluable.

In one case in which our patient had a

FIG. 5. Same patient as in Figure 4, showing a large fluid-gas level in right subphrenic space.

FIG. 6. Reveals that the subphrenic collection of pus is anterior in this lateral upright view.

FIG. 7. Lateral decubitus view reveals the same subphrenic gas fluid level, in the extreme right upper corner of the picture.

proached through an extraperitoneal lateral route without contamination of the uninvolved bowel and peritoneum and with no danger of spreading the infection.

When the abscess is medial to the cecum, the incision is made more medially and may have to invade the peritoneal cavity. In

subphrenic abscess following a perforated peptic ulcer, our roentgenologic examination revealed a second smaller abscess in the lower pelvis, medial and inferior to the cecum. Digital examination subsequently revealed this abscess to be perirectal, and when the subphrenic abscess was surgically

invaded, the perirectal abscess was drained very simply by a stab wound through the rectum.

the mobility of the diaphragm. We then turn the table upright so that the patient is in a standing position and we look for a gas-

FIG. 8. Reveals a second abscess in the same patient with a fluid level in the right side of the pelvis. The arrow is within the gas portion of the abscess.

In subphrenic abscesses with fluid levels, a right lateral film with the patient in the upright position may be of value in determining whether the abscess is anterior or posterior. In (Case 11, Figs. 4, 5, 6, 7 and 8), the abscess was shown to be more anterior and the drainage, instituted through the anterior abdominal wall, secured approximately 2,500 cc. of purulent material.

In making roentgenologic studies of these cases, it is wise to follow a certain routine sequence. We always do a complete fluoroscopic examination before exposing any films. We first examine the patient lying on his back on the horizontal table, so as to get some idea of where the opacity is and in what portion of the abdomen the abscess is located, as well as to observe the chest and

fluid level in the involved area. Then the patient is placed on a cart in front of the vertical fluoroscope, lying on his left side with the right side up, again looking for the extent of the gas-fluid level. In indicated cases a right lateral decubitus view is also of help. It is possible also to examine the patient with a horizontal ray while he lies prone on his back. This permits the determination of contact of the abscess to the abdominal wall. We then take films, one with the patient in each of the above positions. Occasionally, when the abscess is in the right lower quadrant and the cecum cannot be made out fluoroscopically, we inject a small amount of air into the colon through a rectal tube until the cecum is slightly distended. This procedure must be

used with the utmost caution and usually under the fluoroscope, since overdistention of the colon may break up a walled-off abscess.

SUMMARY AND CONCLUSIONS

1. The x-ray examination is of value in determining the site and relations of abdominal abscesses.

2. Fluoroscopic examinations should precede the exposure of films with the patient in the upright and lateral decubitus positions.

3. The relations of the abscess to other viscera and the abdominal wall may be determined by the suitable amount of air as a contrast medium.

* * *
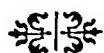
. . . the treatment of most gastro-intestinal foreign bodies in infants and children should be conservative. Of the manifold substances which are swallowed, 95 per cent will be eliminated spontaneously without symptoms and without danger of injury to the alimentary tract.

From—"Abdominal Surgery of Infancy and Childhood"—by William E. Ladd and Robert E. Gross (W. B. Saunders Company).

EXPERIENCES WITH SPOOL COTTON AS A SUTURE MATERIAL*

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THE use of cotton for suturing is not new; however, it is not widely used. The author became interested in cotton following a visit with Dr. Alton Ochsner at Tulane University in January, 1941. Only six months have passed since I have adopted the use of this material in routine surgery. Although I am reporting on only 150 major surgical procedures, I believe some impressions can be reported at this time.

Gage[1] and Guerry[2] have used fine spool cotton sutures for many years. They reported successful results in personal communications to Dr. William H. Meade[3] and Dr. Alton Ochsner. Ginkovskiy[4] also reported on cotton thread as a suture material in 1936. Following the adoption of this material, Meade and Ochsner[3] reported on the relative values of catgut, silk, linen and cotton as suture materials. Their results are worth noting.

Absorbable sutures heal by "wet healing" while nonabsorbable suture materials heal by "dry healing." The wet type of healing is associated with excessive fluid exudate and a delayed appearance of fibroblasts. The dry type of healing produces a minimal amount of exudate and fibroblastic proliferation appears early. (Fig. 1.) These two factors, namely, excessive exudation and delayed fibroblastic proliferation, which are associated with catgut sutures, delay wound healing. Our experiences with silk and linen have been quite large. Prior to the adoption of cotton we used Pagenstecher linen almost exclusively. The annoyance to both patient and surgeon caused by a draining piece of silk cannot be overemphasized. Since the adoption of cotton as a suture material, we have to date seen no draining sinuses.

Cotton is a vegetable fiber which is easily obtainable. It is inexpensive and easy to sterilize. Cotton fibers have a natural tendency to twist upon themselves. This is not the case with linen and silk. This twisting property of cotton makes it quite impossible to fray out as does linen and silk. Because of this twisting it is difficult for leukocytes and granulation tissue to make any appreciable ingrowth into the suture. Such ingrowths take place quite readily with silk and linen. This may be the explanation for the absence of draining sinuses with cotton. When cotton is spun, it is made up of six cords. There is a mercerized cotton which has a greater tensile strength than natural six-cord cotton. Mercer, in 1930, placed cotton thread in a warm 25 per cent solution of potassium hydroxide for an hour. This produced a shrinking of the fiber with a resulting increase in tensile strength.

Sterilization of this suture material is not difficult. Cotton sutures may be steam autoclaved for ten minutes at fifteen pounds pressure or boiled for twenty minutes. It has been found that if the cotton is wrapped for various lengths around ordinary rubber tubing its tensile strength will not be diminished.

It is a well established fact that the finer the suture material used, the better the result. The days of the No. 3 double chromic catgut seem to be rapidly disappearing. Tissues that have to be pulled together forcibly do not belong together.

We have tried to standardize the technic for cotton usage. No. 24 spool cotton

either white or black may be used as a single unit cotton technic. K. P. A. Taylor,[5] of Panama, describes this single

FIG. 1. Anchoring cotton suture removed from common duct on twelfth postoperative day. Note leucocytic response around the suture but no infiltration into suture structure proper. × 260.

unit technic quite clearly. We believe, however, that No. 24 cotton is too thick to be buried in the subcutaneous fat and in suturing of serous surfaces. Therefore, we utilize No. 80, No. 24 and quilting cotton. No. 80 is a very fine cotton thread and requires careful handling. It is used for superficial vessels and in subcutaneous suturing. Quilting thread is equivalent to about a size 50 and has good tensile strength. It is used for all seroserous sutures including purse-string sutures. No. 24 is the suture material which we utilize most extensively. To avoid confusion on our service at the Cook County Hospital of Chicago, we have utilized this single unit No. 24 technic. In other words, No. 24 cotton is used for everything; this means ligating, suturing tissue stumps, vascular

pedicles, peritoneal closure, fascial closure, etc. To date we have noticed no ill effects.

Taylor[5] advocates the use of cotton as a
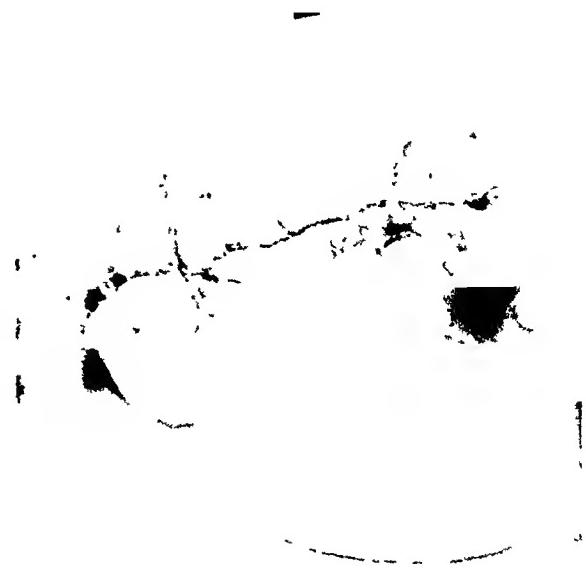
FIG. 2. Supracondylar leg amputation for diabetic gangrene; fourteenth postoperative day; No. 24 interrupted cotton used throughout; no drain.

continuous suture. We, however, have been following the teaching of Halsted, namely, to use nonabsorbable material only as interrupted sutures. It may be argued that this is a long and tedious type of technic but with an operating team that is familiar with this routine, very little time is lost. All of our serosal suturing in gastrointestinal work as well as peritoneal closure and fascial suturing has been done with interrupted sutures. We have had no reason to regret this type of suturing and to date our operating time has been prolonged but little. The incidence of evisceration as well as leaks due to insecure gastrointestinal suturing was entirely absent in our series of cases.

To obtain best results with cotton the assistant should be instructed to cut the sutures as close to the knot as possible. Dr. Michael de Bakey has devised a special scissors for this purpose.

In our utilization of cotton we have attempted to take cases as they came. Whether the case was an interval appendix or a perforated appendix with an already

contaminated wound made no difference. Our series includes such cases as thyroidectomy, mastectomy, gastroenterostomy, gastric resection, Mikulicz procedures for large bowel neoplasms, appendectomy, pelvic surgery, cholecystectomy, common duct drainage, hydrocele, vein ligation, herniorrhaphies, suturing of wounds of the face and amputation stumps. (Fig. 2.) To date we have not used cotton in vaginal or rectal work but it has been used in these regions. We have sutured tendons with routine cotton technic which resulted in good healing and good function.

In gastric resections we have utilized interrupted quilting cotton throughout with the exception of the through-and-through suture line No. 2. For this we use a No. 00 plain continuous catgut. Some surgeons object to the use of absorbable and nonabsorbable materials in the same case. We have never hesitated to use catgut for the through-and-through suture and have had no cause to regret it.

Although we have intentionally used cotton in grossly contaminated wounds for the sole purpose of determining whether or not a sinus would form, up to the present time we have seen no such tracts develop.

I do not wish to state that such wounds never drain. They drain when contaminated and infection ensues. In such eventuality the drainage subsides within a period of from fourteen to eighteen days and the wound heals. We have not been this fortunate with the use of silk and Pagenstecher linen and have abandoned the use of these. Although only nine months have elapsed since the beginning of our use of this suture material, we believe that our efforts were worth while and that our enthusiasm for cotton is justified. Cotton was used as early as 500 B.C. by Susruta.

CONCLUSIONS

1. Experiences with cotton as a routine suture material are reported.

2. Cotton has been found to be a very satisfactory suture material.

3. Its tensile strength in tissues does not diminish as does that of catgut, linen and silk.

4. It is easy to sterilize and is inexpensive.

5. It can be buried in infected wounds without resulting sinus formation.

6. It results in rapid, dry healing without serum accumulation and can be used as a routine suture material.

REFERENCES

1. GAGE, I. M. Personal communication from Wm. H. Meade and Alton Ochsner.
2. GUERRY, LeGRAND. Personal communication to Wm. H. Meade and Alton Ochsner.
3. MEADE, WM. H. and OCHSNER, ALTON. Spool cotton as a suture material. *J. A. M. A.*, 113: 2230–2231, 1939.
4. GINKOVSKIY, V. M. Cotton thread as a suture. *Vestnik. khir.*, 44: 27, 1936.
5. TAYLOR, K. P. A. Single unit cotton thread surgical technic. *South. Surg.*, 10: 125–131, 1941.

TREATMENT AND CURE OF SEVENTY-SIX CASES OF HYDROCELE BY ONE TWIN-INJECTION OF LITHIUM SALICYLATE AND QUININE HYDROCHLORIDE AND URETHANE

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I BELIEVE that this treatment of hydrocele can replace surgery in all carefully selected cases and save the patient loss of time and also money. All the seventy-six cases were carefully selected from two points of view: First, there had to be no previous tapping or treatments received by such patient. Second, there had to be no other conditions associated with hydrocele, such as hernia or varicocele when this treatment was given. Also the diagnosis had to be certain that it was a hydrocele that such a patient was suffering from, as there are such conditions as spermatocele or malignancy which can be mistaken for hydrocele.

The majority of these patients treated were men for whom confinement in bed for even only a few days might have proved fatal because they were suffering from bad cases of asthma and myocardial failure. This treatment cured them without any setback. The most time lost by any of this series was three days. Every patient was treated in my office and after five to ten minutes' rest they walked out with the end result a complete cure. The first patient treated has had no recurrence after seven years.

Since the commencement of this treatment seven years ago, two of these patients died of myocardial failure four and five years, respectively, after the treatment for hydrocele, and I was fortunate enough to obtain for pathological examination in both cases the scrotum and testes and found complete adhesions of what was formerly the sack of the hydrocele. The wall was completely adherent around the covering of the testicle with no spaces and the scar tissue was not that which we see after a strong irritant is used, but of soft elastic fibrous tissue.

The formula used for this treatment consists of two compounds: (1) 30 per cent lithium salicylate containing 1 per cent tutocain, (2) 2 per cent quinine hydrochloride and urethane.

TECHNIC

Under strict aseptic surgical technic a 10 cc. syringe is loaded with 4 to 6 cc. of lithium salycilate, another 10 cc. syringe is loaded with the same amount of quinine urethane, and one 2 cc. syringe is loaded with sterile water. The scrotum is shaved and washed off with ether and alcohol or any other antiseptic solution. A local injection of about 1 cc. of 1 per cent novocaine in a 2 cc. syringe with a small hypodermic needle is given in the scrotum subcutaneously to render the procedure painless. After the novocaine is injected I insert the needle directly into the cavity. Upon withdrawing the piston, pure amber colored fluid appears in the syringe. This further clinches the diagnosis.

With the eye on the point where the needle penetrated the sack and my left hand grasping the scrotum firmly, I withdraw the needle and push home a 16 gauge spinal puncture needle just far enough to penetrate into the cavity for about half an inch. This needle is only two inches long with a short bevel and is safer to use in such cases. The stylet is now withdrawn, a 30 cc. syringe attached and the sack gradually emptied completely of the fluid. The

syringe is now detached from the spinal needle and the syringe containing the lithium salicylate is attached to the needle and injected into the sack. This syringe in turn is detached and the syringe containing the sterile water is attached to the needle and flushed through with about 1 cc. of sterile water and detached, and then the syringe containing the quinine urethane is injected into the sack. When these two compounds come in contact with each other, they immediately form a very firm, sticky substance.

With the needle still in *situ* and the thumb and finger of the left hand tightly around the needle the hydrocele coverings are gently kneaded with the right hand. The needle is now withdrawn and a piece of elastoplast, the size of a silver dollar, over a pledget of absorbent cotton is placed over the puncture. The patient is allowed to lie quiet from five to ten minutes and is then permitted to get up, wearing a jock strap. He is told to rest in bed for one or two days and if soreness and much swelling occur, he is to apply an ice bag to the scrotum and support the scrotum with a pillow between his legs for twenty-four to forty-eight hours. The swelling that appears reaches its maximum within twenty-four hours and then begins to subside gradually. Within two months one can not tell on which side the hydrocele was originally. On the second or third day the majority of patients have felt well enough to return to their daily routine. All these patients, of course, wear the jock strap until the swelling has subsided.

SUMMARY

Seventy-six patients with hydrocele have been treated and cured by the method of one twin injection of lithium salicylate and quinine hydrochloride and urethane. The average loss of time was two to three days. No hospitalization was necessary in any one case of this series. No complications occurred and there was no setback in any of the patients who suffered from myocardial or pulmonary conditions.

This method, if used in carefully selected cases, may do away with the hazard of surgery and save money and time for the patient.

SURGICAL TREATMENT OF LUPUS OF THE SKIN*

CASE REPORT

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ALTHOUGH the surgical treatment of lupus is not new, it has not yet met the recognition it deserves, especially among dermatologists who are usually the first to see these patients.

As far back as 1890, Vatrin (France) treated lupus by excision and skin grafting. Nelaton (France) and Lang (Vienna) also reported favorably on surgical therapy at the IV International Congress of Dermatology[1] in 1900. With the popularization of Finsen therapy, however, conservative treatment gained the ascendency.

Cauterization, scarification and radiation therapy have often been successfully used in the treatment of lupus. Many cases, however, derive no benefit from these methods, even when employed with the utmost skill. Some do not heal at all; others recur after a temporary seeming cure. In this group surgery is the only resort.

Surgical method of treatment consists of wide excision of the involved area and a safe margin of healthy tissue. The skin is removed in its entirety, together with a thin layer of subcutaneous fat, as lupus lesions usually tend to spread deep into the derm as well as superficially.

During surgery, inoculation of healthy skin must be avoided. Indiscreet use of instruments in handling the tissues is sometimes responsible for recurrences. Injection of an anesthetic through the diseased skin may also be an inadvertent agent of tuberculous inoculation.

Following excision of the lupus area, the raw surface can be skin grafted at once or left to granulate for a short period of time to enhance the taking of the graft. I prefer immediate skin grafting following excision as this simplifies the postoperative care. If part of the skin graft fails to take or becomes the seat of recurrence, the troublesome area can easily be re-grafted later on.

Delay in skin grafting, following excision of lupus area, has the advantage supposedly of improving the blood supply of the wound and permitting elimination of bacteria which might cause a recurrence. However, since a split (thin) graft is used in this type of repair, delay is unnecessary, because of the ease with which a thin graft can be procured.

Following excision of even a small lupus area, it is not usually advisable to try to close the defect by shifting the surrounding skin, because of the possibility of recurrence. This method can be used, however, in cases in which temporary skin grafts have been previously applied and the area has remained free from lesions for a prolonged time.

Tubed flaps are contraindicated for skin covering following lupus excision because of the undue amount of surgery involved in the preparation of these flaps and the danger of recurrence.

The indications for surgery depend upon the size and location of the lesion and the social status of the patient. Small localized areas on any part of the body or face, not involving a cavity or its margin, may be excised for economic reasons, to avoid the protracted treatment usually required in conservative procedures. On the other hand, there are certain *contraindications* which must be strictly respected. Surgery

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* Case presentation before the Society of Plastic and Reconstructive Surgery, 1940.

is not indicated in recent cases with rapid extension or in those without definite localization. Neither should it be attempted

Fig. 1. Lupus vulgaris of the ear and cheek with malignant degeneration of auricle following prolonged treatment including intensive radiation therapy.

when the lupus involves margins of cavities, such as the mouth, nostrils, eyelids, etc.

As a general rule, one may say that surgery is indicated in those types of skin lupus which are fairly well localized, without tendency to spread, and which resist all conservative therapy. The indications for surgery are strengthened when the lupus lesions have been exposed to radiation therapy for a prolonged period of time with danger of malignant degeneration.

The following case report illustrates the potential danger of protracted treatment of skin lupus and the beneficial results of surgery in such cases:

CASE REPORT

A woman, age forty-two, had been treated continuously for an active lupus vulgaris in a number of dermatological clinics for about fifteen years prior to her appearance in the plastic surgery clinic. The site of the lesion was the left cheek and auricle. Treatment had been of various types, including x-ray therapy. According to her history, lupus on the ear

had been in existence for about thirty-three years and on the cheek for twenty years. When I first saw the patient in June, 1933, the lupus

Fig. 2. Same patient eight years after amputation of auricle, with wide excision of diseased skin of cheek, followed by free skin grafting. There was no recurrence after surgery.

area extended on the posterior half of the left cheek with active lesions disseminated in an irregularly scarred skin. The left ear had a cauliflower appearance and lobulated, inflamed and ulcerated. In the previous few weeks the ear had become excrutiatingly painful and the swelling had progressed rapidly. No lupus lesions were to be found elsewhere on the body and no other tuberculous process was diagnosed. The tuberculous condition seemed to have been localized on the left cheek and ear for at least two and three decades, respectively, without any tendency to spread. (Figs. 1 and 2.)

Pathological examination of a specimen removed from the diseased auricle revealed a squamocell epithelioma. (Fig. 4.) The auricle was amputated with a diathermy knife in July, 1933. There has been no recurrence in that area since.

The patient continued to be treated in the dermatological clinic for skin lupus of the cheek until about 1935. In July of that year, the entire lupus area, as outlined in Figure 3

was excised with a margin of healthy skin of about one-third of an inch. The wound surface appeared greatly scarred with a poor blood
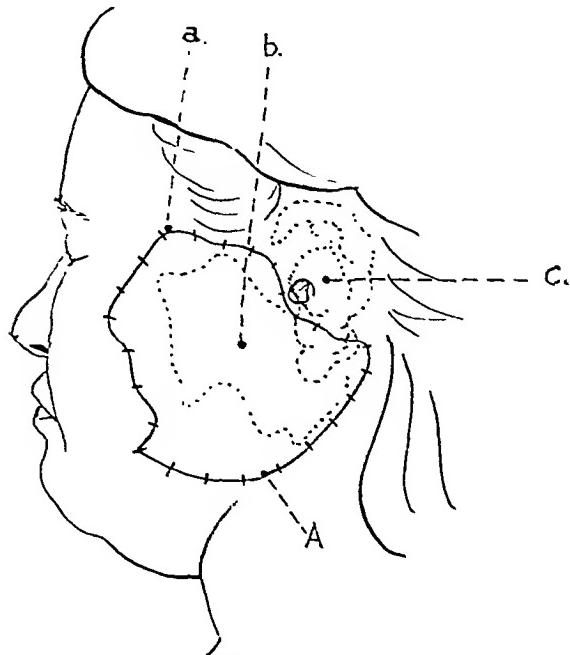
FIG. 3. Diagram outlining free skin graft and its relationship to the lupus areas. *a*, free skin graft; *b*, lupus area of the skin; *c*, amputated oriele.

supply. All scar tissue above the fascia was carefully excised, with proper regard for preservation of the branches of the facial nerve. A thick split graft from the abdomen was sutured into the defect. The usual pressure dressing, with a sea sponge maintained by retention sutures, was applied. The surgery was done in one stage under local anesthesia. (Fig. 2.)

The patient has been seen by us periodically in the eight years since the operation and there has been no recurrence of lupus or epithelioma observed in either the graft or the stump of the auricle. The texture and color of the graft have gradually improved with the passage of years.

SUMMARY AND CONCLUSIONS

1. Surgery is the only resort in lupus cases unaffected by conservative therapeutic measures.

2. Contraindication for surgery exists in rapidly spreading lesions without definite localization and in those involving margins of cavities.

FIG. 4. Microphotograph of specimen taken from ear tumor showing squamocell epithelioma grafted on lupus with secondary acute infection.

3. The surgical procedure of choice is wide excision followed by free skin grafting.

4. A case of lupus vulgaris of cheek and ear of over thirty years' duration is here described. Continuous irritation with physical and chemical agents during prolonged treatment of the lupus had caused malignant degeneration of the ear. There have been no recurrences of either the lupus or the malignancy since surgery.

REFERENCE

1. E. Lang. Sur les resultats de l'extirpation du lupus avec presentation des malades operès et gueris. M. Nelaton. Discussion of this paper-iv. Congress International de Dermatologie et de Syphilographie. Paris, pp. 160–165, August, 1900.

ECONOMIC CONSIDERATIONS OF COSMETIC SURGERY

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FOR a long time the economic aspects of certain plastic operations have been overshadowed by their cosmetic results. This was emphasized several years ago when a fellow member of a hospital staff asked me to do a cosmetic operation on his eyelids. He was the quiet, conservative type, a successful surgeon of twenty-three years' practice. He related an unpleasant experience: An old patient, a woman, had commented adversely on the appearance of his wrinkled and puffy eyelids. Dissipation was intimated. Disturbed, he spoke to his secretary about it and was surprised to learn that she had heard similar remarks. Being of a sensitive nature, he was embarrassed and began to fear loss of his practice. He decided that the most desirable thing to do was to have this condition corrected through a plastic operation. This was accomplished with the result that his appearance was made more youthful and his fears dispelled.

One of my early face-lifting operations was done on an actress who had enjoyed a successful career but had lost everything due to bad financial management. Well past middle life, she was still vigorous, a seasoned and experienced artist, but was unable to work at her profession because of the greatly wrinkled and relaxed skin of her face.

After a successful face-lifting operation she was able to return to her professional activity which was her one means of earning a living. Once more on her feet financially, her self-confidence and popularity restored, she proceeded to write her autobiography, the sale of which continues a source of income to her.

Respect for cosmetic surgery has increased during the past decade. Appreciation of its economic value is more widespread. Middle-aged persons frequently report that a youthful appearance is a more desirable qualification than experience in getting a job. Patients seeking this type of surgery for economic reasons come from many fields of endeavor.

SELECTION OF PATIENTS

In a judicious selection of patients for operation the surgeon is obliged to refuse a fair number for the following reasons: It should be emphatically impressed upon the patient that no miracles are to be performed. Only a more youthful appearance will result with a diminution in the size and number of wrinkles and folds of the face and neck. For the well-balanced, reasonable person, this is a distinct improvement which is thoroughly appreciated. Unless the surgeon is certain that the patient will take a sensible attitude toward the results, he will save himself considerable trouble by refusing to operate.

PREPARATION FOR OPERATION

Preparation must be complete. The night before the operation the patient's hair is clipped and shaved in that part of the scalp where the incisions are to be made. After shampooing, the scalp and hair are soaked in tincture of metaphen and wrapped in a sterile dressing. Just before the operation, the scalp and hair are again soaked in tincture of metaphen and the face and neck painted with the same solution. Soaking of the hair in this way insures asepsis and keeps the hair out of the wound. It is well to occlude the external auditory canal with sterile cotton to prevent its filling with fluid.

ANESTHESIA

Patients prefer local anesthesia and it possesses certain advantages for the opera-

tor. Novocaine 2 per cent containing 15 to 20 drops of adrenalin per ounce, supplemented by extensive injections of nor-

OPERATION

To obtain best results, the operation is done in at least two stages: first, the
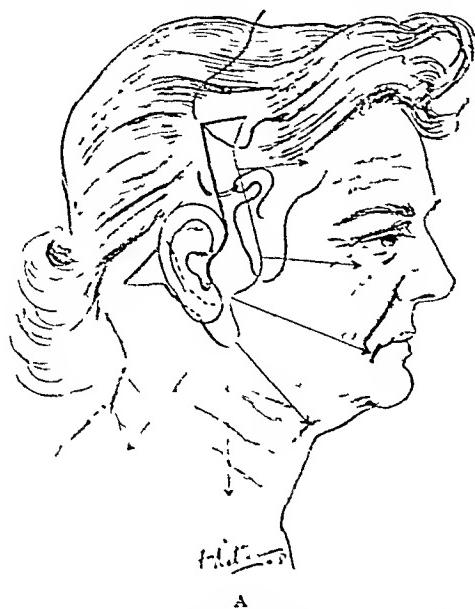
FIG. 1. A, shows incision, pattern and amount of skin to be excised. Arrows denote direction and extent of undermining. Sutures demonstrate skin being elevated to new position. B, shows position of suture line after closure. Hair can be combed backward and downward immediately after removal of sutures, concealing the scar.

mal saline solution. This serves the purpose of diluting the anesthetic, making it easier to obtain a plane of cleavage and elevating the skin and superficial tissues further from the seventh nerve and the nutrient vessels supplying the skin and cartilage of the external ear. Also, there is less bleeding and one may at any time

cheeks and neck, and if necessary, the forehead; followed in from ten to twelve days by the eyelid plastic operation and any minor corrections that will be mentioned later. In Figure 1 A are shown the line of the temporal-peri-auricular incision and the pattern and amount of skin to be removed. Arrows denote direction and
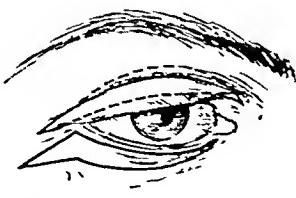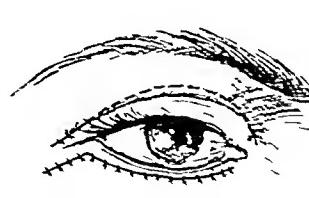
FIG. 2. A, shows incision and pattern of skin to be excised from the eyelids. B, shows position of scar line after sutures are removed.

ask the patient to perform various degrees of facial expression. Sufficient preparation for the anesthesia consists of 3 gr. of nembutal by mouth, given in divided doses; one-half the dose the night before the operation, the remaining dose two hours before the operation, and $\frac{1}{3}$ of a grain of pantapon given hypodermically one-half hour before beginning the anesthesia.

extent of skin undermining. Proceeding cautiously is protection against injury to pre-auricular vessels and aids in finding a plane of cleavage, but once found the dissection can be accomplished rapidly. The slight bleeding can be controlled with hot pads. Ligatures are seldom required, but if needed, they should include a minimum amount of tissue, thus prevent-

ing fibrous nodules from forming under the skin. The greatest bleeding occurs in the scalp and therefore this part of the incision tion of the facial skin. Fine hooked retractors really serve better for holding the tissues. The extent to which the skin is

FIG. 3. A, lateral view of patient before operation. B, lateral view of patient after operation.

FIG. 4. A, frontal view of patient before operation. Note lateral eccentricity of chin and subcutaneous appearance of mandible just below right angle of mouth. B, frontal view of patient postoperatively. Note correction of depression in cheek accomplished by dermofat graft placed through submental incision. Folds about the cheeks and mouth are smaller and fewer. The same is true of the neck.

is made last. The use of tissue forceps, if largely dispensed with, will prevent trauma to the wound edges and permit a more rapid healing. Also it will prevent scarifica- undermined varies with the individual case. A fairly good immediate result can be obtained with very little undermining. However, an important factor which con-

tributes to the quality of the result is the contractile action of the newly formed fibrous tissue under the skin.

A week after the operation there is a subsiding of the skin of the cheek. It is for this reason that the eyelid plastic operation

FIG. 5. A, lateral view of patient before operation. B, lateral view of patient after operation. Note change in appearance of upper eyelid in profile. Also note that patient does not have to cover ear with her hair.

Sutures in Figure 1 A demonstrate the skin of the cheek being elevated to the supra-auricular position. The greatest tension on the suture line is in the scalp. Heavy braided silk No. 19 sutures serve well to control bleeding and firmly approximate wound edges; also the heavy silk cuts the skin less than the finer sutures. Absolute approximation guards against infection and expedites healing. Fine silk sutures No. 1 will serve to approximate the skin in the peri-auricular area. A few interrupted sutures of catgut placed subcutaneously at the base of the tragus reduce any possible tension at this part of the suture line and snuggle the skin close to the fascia forming the normal pre-auricular escarpment without which an artificial appearance is produced.

Deformities that are inconspicuous may become prominent after an operation if not corrected at this time. I refer to deformities such as inequalities in the lateral halves of a lip or a lateral eccentricity of the chin, very wide nostrils, scars or moles.

is postponed. If the forehead skin shows signs of age sufficient to require operation, it can be shortened by a suprafrontal incision just inside the hair line. In undermining the skin in this area one may encounter large superficial veins and considerable trouble will be saved by carefully dissecting around them.

A pressure dressing is applied to the operated area for from forty-eight to seventy-two hours, which is followed by lighter and smaller dressings. Sutures in the cheek can be removed eight to ten days postoperatively; sutures in the scalp should be left in ten to twelve days. Patients are usually quite comfortable and can get out of bed in forty-eight hours; in fact, some leave the hospital while waiting for the second stage of the operation.

Removal of the redundant skin of the eyelids can be accomplished by using the incision shown in Figure 2 A. The scarline placed near the lower lid border is shadowed by the eyelashes. The wound edges cleanly cut and approximated by the use of fine needles and interrupted sutures of

silk will leave a scar so inconspicuous that it is visible only on studied inspection. Slight undermining of the skin is sufficient.

FIG. 6. Shows patient smiling; no compromise of expression.

Extensive undermining may produce contractile scar tissue. The small amount of bleeding can be controlled by the use of hot pads or clamping; no ligatures are required. Ectropion can be an unpleasant result if too great an excision of the skin is done in either the horizontal or diagonal axis. The greatest tension is placed on the lower lid when the eyeball is rotated up-

ward. I find it helpful to have the patient's eyes in this position when estimating the amount of skin to be removed from the lower eyelid. In the upper eyelid a very large amount of skin can be safely removed but it is not necessary. In fact, too much removal produces an artificial appearance. The scarline here is concealed in the fold of the eyelid, shown in Figures 2 A and 2 B. The sutures are removed in from eight to ten days. As in the cheek operation, the result begins to appear when the scar tissue contracts, making the skin fit more snugly.

Familiarity with the use of these incisions is helpful in operating for other conditions about the face. I have used the cheek incision to advance skin upward to the hair line or downward over the mandible or toward the ear to remove or conceal visible scars of the face; also, in repairing injuries to the cheek where a sliding graft of retro-auricular skin is to be advanced into the pre-auricular area, giving skin of similar tint to the face; in elevating the skin of the cheek after doing a muscle transplant for the relief of seventh nerve destruction and also for the cosmetic removal of cheek tumors. I have used the upper eyelid incision to remove a dermoid cyst from under the eyebrow and forehead, and the lower lid incision for the removal of small tumors high up in the cheek; and the suprafrontal incision is used for the removal of tumors of the forehead.

TREATMENT OF POSTOPERATIVE PARATHYROID TETANY WITH OVARIAN HORMONES

REPORT OF TWO CASES

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IT has been frequently observed that hypoparathyroid tetany occurs or increases in severity at the menstrual period (Holtz,[7] Hoxie,[8] Swinton[16]). No definite explanation of this phenomenon has been forthcoming. One reason offered has been the loss of calcium in the blood. It is highly questionable that the loss of calcium in the menstrual flow could account for the onset of tetany even in someone with hypoparathyroidism. Furthermore, as pointed out by McCullagh and Kearns[13] the attack may precede the menstrual flow. In fact in our own two patients, symptoms of tetany usually were noted about twelve hours before the period started.

There is reason for suspecting a close relationship between the sex glands and the mechanism which regulates the calcium level. It has been suggested that the ovaries are part of this mechanism. Those authors who have had the opportunity to observe cases of postoperative tetany have remarked on the large proportion of females who are afflicted (Freyburg,[6] Swinton,[16] Spingarn and Geist[15]). This may be due to the great number of thyroidectomies done on women. At the Mayo Clinic, for example, the proportion of females to males was 3 to 1 (Boothby[4]). One is struck, however, by the fact that in the Mayo series of 13,300 thyroidectomies with a tetany incidence of 1.5 per cent there is not one case of tetany in the male.

The similar chemical structure of the sex hormones and vitamin D also seems significant. These substances are related to the sterols. According to Dodds, Cook, Hewett and Lawson ergosterol possesses estrogenic activity (Kurzrok[9]).

The occurrence of tetany in pregnancy points to an endocrine influence. One can of course, attempt to explain this on the basis of the withdrawal of calcium for fetal development. Zondek[18] believes it to be due to a disturbance of equilibrium in the endocrine system which governs calcium metabolism. Bodansky and Duff[3] consider the possibility of a disturbance of the parathyroids in pregnancy but see no gonadogenic etiology.

Unfortunately, the investigations concerning the influence of the gonads on the calcium level have been conflicting. The experimental results to date can be divided into three groups: (1) Those who claim no influence of the sex hormones on the calcium level; (2) those who claim a decrease in the calcium level and occurrence of tetany, and (3) those who claim an increase in the calcium level.

1. Cheymol and Guinquand removed the ovaries in dogs and found no change in the calcium level (Kurzrok[9]). Marlow and Koch[11] after experimenting with fowl and rats conclude that "to assume that an ovarian hormone controls the level in pregnancy is not well founded." Bodansky and Duff[3] were unable to convert latent into active tetany in rats by the injection of human placental extracts.

2. Holtz and Rossman[7] carried out experiments on dogs using both male and female sex hormones. They conclude that follicular hormone (estradiol benzoate) causes a drop in blood calcium and even acts as an antagonist to dihydrotachysterol. It should be noted here, however,

that the decrease in calcium was slight, 1 to 2 mg., not much more than might be expected as a deviation within normal limits. They found no significant change after progesterone or androsterone administration. They recommend x-ray castration although the cure is not permanent. The latter fact is not explained by them. The dihydrotachysterol need, according to these authors, drops after castration but the blood calcium levels are not given. Hoxie[8] describes a case treated by x-ray castration with no relief until parathormone was given. Mathieu and Barnes[12] found that theelin and theelol decreased the blood calcium in thyroparathyroidectomized dogs. Here again there is no great change in the calcium level. Maranon, Richet, Pergola and Lesueur[10] found that the administration of estrogen to a female patient caused latent tetany to become active while corpus luteum substance had the opposite effect. They speak of a "premenstrual estroginemia."

3. Doisy[5] demonstrated an increase in the serum calcium of birds after massive doses of estrogen. Similar results have been reported by Allen.[1] Riddle and Dotti and Pfeifer and Gardner[14] report a rise in the blood calcium of pigeons after the administration of estrogen. Bach[2] gave estrogen to female rats and found an initial fall in the excretion of calcium followed by an increased excretion.

This problem concerning the relationship of tetany to the menstrual period occurred to me in treating a patient with postoperative tetany. Her symptoms were not severe except at the beginning of the menstrual flow. Shortly before the menses she had mild symptoms and not infrequently at this time actual attacks of tetany. These attacks responded to calcium therapy and we were about to start dihydrotachysterol to prevent them but the question as to why the tetany appeared only at the beginning of menstruation remained unanswered.

At the end of the premenstrual phase the concentration of ovarian hormones in the blood is low. This is especially true of the corpus luteum hormone (Kurzrok[9]). I wondered whether there might not be some relation between the calcium level and the hormonal concentration. With this in mind 5,000 International Units of estrogenic hormone were given to the patient, who claimed the next day that she felt much better. This, of course, was highly subjective and it was decided, with the permission of the patient, to carry out the experiment in greater detail. In addition, I was fortunate to have another patient whose monthly attacks at the menstrual period could not be controlled with even 12 cc. of dihydrotachysterol daily.*

METHOD

Each patient was treated at the menstrual period with estrogen, progesterone or a combination of both in oil injected intramuscularly. The estrogenic substance was estrone. Blood specimens were taken at about 10 A.M. Calcium determinations were made almost daily during the menses and the patients were asked to note subjective symptoms. On patient No. 2 so many blood specimens had been taken that at times we had to forego a few tests so as to spare her veins. The calcium determinations were done by the modified Cramer and Tisdall method.[17]

CASE REPORTS

CASE I. F. R. P., a white, married female had a bilateral thyroidectomy on April 14, 1934, at the age of twenty. Pathological report was: Diffuse macrofollicular colloid hypertrophy of the thyroid gland. She had an uneventful postoperative course and was discharged from the hospital on April 21. That evening the patient noted stiffness in the extremities and during the first week at home her fingers were stiff most of the time. Her first attack of tetany occurred about three months later. She did not have attacks at first but frequently felt very weak and nervous and vomited. She did not consciously relate her symptoms to the menstrual period but

* I am indebted to Dr. Floyd H. Jones for the opportunity to treat this patient.

remembers that after the operation she stayed away from school the first two or three days of each menses. In 1939, she became quite stiff during a menstrual period and was hospitalized. No blood calcium determinations were done during any of these episodes so that there is no report of a low calcium. It was questionable at the time whether the patient had attacks of tetany or hysteria. She began to take 90 gr. of calcium gluconate daily but still had trouble about once a month.

I first saw the patient about the Spring of 1940. At that time she was having a typical tetany attack with carpopedal spasms and a positive Chvostek. The condition was relieved by intravenous calcium. I saw the patient during several menstrual periods. The attacks became more frequent and more severe. Even when she had no attack she had a positive Chvostek and felt miserable. Since her condition was not as severe as that of patient No. 2 we were able to hold off ovarian therapy until her symptoms were upon her and her calcium had dropped. She was not very co-operative so that we managed to carry on the experiment for only a short time. Ovarian therapy was begun on September 9, after which her calcium level rose and she improved rapidly. After a few months she felt better generally and since it was difficult to get her into the office for injections and calcium tests, dihydrotachysterol was started. This is taken now only at the menstrual period.

CASE II. S. A. L., a white, unmarried female had a bilateral thyroidectomy on November 3, 1938, at the age of twenty-two. The pathological report was: Diffuse colloid goiter and one parathyroid body. The patient was quite restless postoperatively and vomited frequently. That night she was nervous, had a severe headache and slight epistaxis occurred. The next day she complained of numbness in the arms and legs and in the evening appeared "exhausted." On November 7, she began to cry because of pain in her hands. The hands and feet began to stiffen, the jaw became stiff and typical carpopedal spasms occurred. Ten cc. of calcium gluconate and 10 cc. of calcium levulinate intravenously brought relief, after which calcium gluconate $-1\frac{1}{2}$ gr. every four hours by mouth was started. Her menses began about 11 A.M. on November 8, and on that day she had an attack of tetany. This, like all her tetany attacks was treated

with calcium levulinate intravenously. She suffered attacks of tetany intermittently, the last one of the month occurring on the twenty-fifth. The next menstrual period began on December 6 and on the 7 she was in tetany. On December 10 the administration of dihydrotachysterol was started with 30 m. daily. The stiffness continued and hence the dihydrotachysterol was increased to 40 m., and 1 cc. of parathormone was given daily. The parathormone was discontinued after a week but the dihydrotachysterol was gradually increased to 8 cc. in one day. In the meantime daily calcium determinations were being done and the dihydrotachysterol regulated accordingly. The menstrual periods were regular and the patient had no more attacks for a time although she was quite stiff, had to go to bed and was given calcium intravenously at every menses. It should also be noted that except on the rare occasion when the calcium level was above ten the patient always had at least a slight Chvostek sign. The Trousseau sign was positive only when the Chvostek was marked.

From December 14 until the month of March the patient was free from actual attacks. In March, an attack of tetany occurred in spite of the administration of 12 cc. of dihydrotachysterol. Tetany again occurred in July and an extremely severe attack in August. There were attacks of lesser severity at other periods.

Early in 1940 the patient began to have typical tetany attacks every month. Between the menses the daily dose of dihydrotachysterol was gradually reduced to 2 cc. About two days before the period was expected the dihydrotachysterol was increased to 6 cc. and on the day the period started she was given 12 cc. In spite of this the monthly attacks continued. In August, she suffered an unusually severe attack which left her extremely weak. Because of the apparent hopelessness of the situation x-ray castration was being considered.

On September 17, ovarian hormone therapy was started. The hormones were administered a few days before the period was expected and continued until the danger of tetany was past. The variation in the time of the initial injection in relation to the beginning of the menstrual period (Table III) is due to the delaying action of the ovarian hormones on the menses and also, of course, to the occasional variation in the periods themselves. The treatment was repeated for five periods during

which the patient had no attacks of tetany and only mild, transient symptoms such as tingling in the fingers. One cc. of parathormone was given once for such symptoms after the September period.

At the end of January, 1941, her blood calcium rose to 12.1 mg. per cent (Table III) and the patient displayed symptoms of hypercalcemia including nausea and extreme lassitude. All medication and calcium were stopped. At this time a small, firm nodule about 1 cm. in diameter was noted in the center of her neck over the thyroid cartilage. This nodule was definitely not present two months before and has not grown appreciably in size since its discovery.

The patient received no more ovarian hormones after January 28. She had one attack of tetany between the February and March menstrual periods but none since then. During the March menses 6 cc. of dihydrotachysterol were given daily for three days. The calcium gluconate has been decreased to 60 gr. daily and the intermenstrual dihydrotachysterol to 0.5 cc. daily. The patient is a little weak during the menses and the blood calcium dropped at one time to 6.6 mg. per cent but there have been no marked symptoms of tetany. The lowest calcium level between the menstrual periods has been 7.6 mg. per cent.

COMMENT

Table II contains one period of Case II when she received dihydrotachysterol but no hormones. The other tables show the results of ovarian administration during the menses.

In Table I we see that there was not only improvement in this patient's condition after the symptoms became manifest but there seems to be even a corresponding rise in the blood calcium. It will be noted in Table III that the blood calcium dropped as low as 5.0 mg. per cent. Previous to the institution of this form of therapy when the patient received only calcium and dihydrotachysterol the lowest calcium level was also 5.0 mg. per cent but she had repeated attacks of severe tetany. It can also be seen that tetany does not necessarily always occur at the lowest calcium level.

I suspect that the nodule in the patient in Case II is parathyroid tissue which, however, was not present when the ovarian therapy was begun. It would indeed be a strange coincidence if any remaining para-

TABLE I

TREATMENT IN CASE I WITH OVARIAN HORMONES DURING MENSTRUAL PERIODS

Date	Estrogen I. U.	Progesterone Mg.	Blood Ca. Mg. Per Cent	Clinical Notes
9-7			9 1	Breathing sl. difficult
8			8 9	Same; menses started
9		2	6 5	Nervous; tired; feels "stupid"; nausea
10			7 9	Same in A.M.; better subjectively in P.M.
11			9 4	Breathing much better; sl. nausea
12				No nausea; feels good; menses stopped
13			9 6	Feels fine
10-5				Nervous; irritable; breathing sl. difficult
6			10 7	About the same
7	10,000		5 2	Breathing very difficult; "stupid"
8	10,000		7 5	Better; more alert; breathing same
9	10,000		9 0	Does not feel "stupid"; menses
10			7 8	Worse last night; better this A.M. Good in P.M.
11			9 0	Good
14				Fine; menses stopped
12-3				Good until today; sl. nervous
6	5,000	5	9 4	Breathing difficult; nervous; "stupid"
7			9 6	Sl. better
8			7 5	Definitely better; nervous; not "stupid"
9	5,000	5	9 0	Same
10	2,000	1	8 2	Good except headache
11	.			Much better
15				Fine; menses stopped

thyroid tissue just happened to start growing when the treatment was instituted. In both cases progesterone seems to have been more effective. I do not know what effect other estrogenic compounds such as

estradiol might have. In Case II (Table III) the estrogen was decreased because of the possibility that it may have caused the dysmenorrhea.

TABLE II

TREATMENT IN CASE II WITH DIHYDROTACHYSTEROL DURING ONE MENSTRUAL PERIOD

Date	Dihydrotachysterol Cc.	Blood Ca. Mg. Per Cent	Clinical Notes
6-22	2	10 7	Good
25	6	.	Good
26	6	8 2	Tingling in fingers
2-	12	5 0	Menses started; tetany attack / Calcium i. v.
29	12	6.0	Carpopedal spasm; calcium i. v.
30	12	7.2	Better; still tingling
7-1	6	....	Better
3	6	8.8	Weak but better
6	6	5 4	Tried to get up; felt numb all over
10	2	8.0	Good

We certainly cannot draw the conclusion that the calcium level was kept high by means of this therapy. There are two other possibilities which present themselves. First, the ovaries, although they may have no direct effect on the calcium level, regulate the neuromuscular excitability of the body. This theory has been advanced by McCullagh,[13] and is borne out by Table I in which the patient had a low calcium but no tetany. Secondly, in one patient, the intermittent administration of ovarian hormone over a period of several months may have stimulated the remaining parathyroid tissue to grow. This is very hypothetical since we do not even know for certain that the described tumor is of parathyroid origin. Cramer[4] says that an excess of estrogen can cause a marked enlargement of the parathyroid glands. The patient, however, showed immediate improvement before the nodule was noted. Furthermore, the patient in Case II had relief without the occurrence of any nodule.

TABLE III

TREATMENT IN CASE II WITH DIHYDROTACHYSTEROL AND OVARIAN HORMONES DURING MENSTRUAL PERIODS

Date	Estrogen I. U.	Progesterone Mg.	Dihydrotachysterol Cc.	Blood Ca. Mg. Per Cent	Clinical Notes
9-17	.....	5	2	7 0	Good
18	.....	5	2	.	Good
19	..	5	2	6 0	Fingers stiff for few seconds in A M
20	...	5	2	5 2	Good today
21	.	5	6	6 6	Good; a little weak
22	..	5	6	6 8	Same
23		5	6		Same
24		5	6	7 8	No pep; weak
25		5	6		Better but not much pep
26		5	6	6 3	Menses started last night
2-		5	6	5 6	Good, no symptoms of tetany
28			6	8 1	Good
10-19	10,000		6		Feels good
20	10,000		6		
21	10,000	.	6		
22	10,000			6	Tingling in extremities Trousseau positive
23	10,000		6	6 -	Aches all over, menses started and stopped for a few hours / Abdominal cramps
24	.		6	6 -	Better, still has low abdominal cramps
25			6	5 9	Weak, no tetany
26	2,000	.	6	6 4	Weak
2-	5,000		6	5 0	Hands felt numb for few seconds in A M
28			6	5 8	Better but weak
29			2	5 0	Good
11-20	..		2	9 -	Feels good
21	5,000	5	6		Aches all over Sl nausea / No tingling
22	5,000	5	12	6 6	Fingers tingled in A M Better in P M Menses started last night
23	5,000	5	12	7 5	Vomited last night Good today
24	5,000	5	6	5 8	Weak, but feels good Trousseau positive
25	..		6	6 1	Good Not so weak
26	.		6		Fine
28	...		2	7 4	Fine
30	..		2	.	Menses stopped
12-16	5,000	5	2		Felt good until today very weak
1-	5,000	5	2		Still weak
18	5,000	5	6		Weak but no symptoms of tetany
19	5,000	5	6	7 6	Better today
20	5,000	5	6		Weak last night, good today
21	5,000	5	2		Weak during night, better today
22	5,000	5	2		Weak today
23	5,000	5	2	7.0	Better today, still somewhat weak
24	5,000	5	2		About same
25	5,000	5	6	6 8	Vomited last night, menses / No tetany
26	5,000	5	6	6 8	Weak, no tetany
27	5,000	5	6	.	Low abdominal cramps
28	...	..	6	7 5	Better
29	.....	..	2	7 8	Feels fair
1-1	.....	..	6	6 -	Menses stopped, slight tingling in hands
3	.....	..	2	7.6	Feels fine

TABLE III (Continued)

Date	Estrogen I.U.	Pro-gesterone Mg	Di-hydro-tachy-sterol Cc	Blood Ca Mg Per Cent	Clinical Notes
1-21	2,000	5	6		Feels fine, menses due today
22	2,000	5	6		No pep
23	2,000	5	6		Good today
24	2,000	5	6	~8	Fair today, no pep
25	2,000	5	6		Low abdominal cramps
26	2,000	5	6		Menses started, severe dysmenorrhea
27	2,000	5	6	~8	Severe cramps, no tetany
28	2,000	5	6	9.4	Cramps less severe, headache
29				10.1	Nausea, calcium and medication stopped
30				12.1	Menses stopped

Purely from this investigation one cannot recommend the routine use of ovarian hormones in the treatment of tetany. For one thing, in most cases there is no need to look further when we have such a splendid calcium regulator as dihydrotachysterol. I believe, however, that we can definitely conclude that the ovaries have some influence on the condition of tetany. The change from monthly tetany attacks to no attacks during the menses is striking. These results, although not conclusive, warrant further research in the same direction.

It is, of course, difficult to compare this work with that of other similar investigations since the majority of these have used experimental animals. My results, for example, would not tend to substantiate the contention of Holtz[7] that follicular hormone lowers the calcium level and acts as an antagonist to dihydrotachysterol. The latter's experiments were carried out on dogs.

It might be well to note that an attempt was made by us to investigate the action of ovarian hormones on dogs.* Only two dogs were used, one as a control, so that the results are by no means conclusive. We noted, however, no difference in either of the thyroparathyroidectomized dogs after the administration of ovarian hor-

* The experimental work was carried out with the assistance of William K. Nowill, M.T.

mones to one dog. This was also true after the ovaries were removed. Both dogs displayed symptoms of tetany about the same time and their calcium levels showed little difference. It would be interesting to see the results if one parathyroid body were left in situ.

SUMMARY

Two female patients suffering from postoperative tetany had their attacks chiefly at the menstrual periods. Administration of ovarian hormones led to the following conclusions:

1. The ovaries may influence the neuromuscular excitability of the body.

2. In these patients the ovarian hormones did not depress the blood calcium level and they did not act as an antagonist to dihydrotachysterol. On the contrary, in one patient the dihydrotachysterol need seemed to be decreased.

3. The clinical benefits noted in these two patients justifies further carefully controlled study and use of ovarian hormones in similar cases.

Since this article was submitted for publication the patients have received no sex hormone therapy. The patient in Case II has had two moderately severe attacks of tetany.

REFERENCES

1. ALLEN, E. Ovarian hormones and female genital cancer. J. A. M. A., 114: 2107, 1940.
2. BACH. Quoted from Albright, F., Smith, P. H. and Richardson, A. M. Postmenopausal osteoporosis. J. A. M. A., 116: 2465, 1941.
3. BODANSKY, M. and DUFF, V. B. Regulation of the level of calcium in the serum during pregnancy. J. A. M. A., 112: 223, 1939.
4. BOOTHBY, W. M., HAINES, S. F. and PEMBERTON, J. DEJ. Postoperative parathyroid insufficiency. Am. J. M. Sc., 181: 81, 1931.
5. DOISY, E. A. The estrogenic substances. Glandular physiology and therapy. J. A. M. A., 116: 501, 1941.
6. FREYBURG, R. H., GRANT, R. L. and ROBB, M. A. Hypoparathyroidism. J. A. M. A., 107: 1769, 1936.
7. HOLTZ, F. and ROSSMAN, F. Ueber Beziehungen der Sexual-hormone zum Kalkstoffwechsel und zu den Nebenschildruesen. Ztschr. f. Geb. und Gynäk., 116: 199, 1938.
8. HOXIE, G. H. A case of parathyroid deficiency. Endocrinology, 16: 358, 1932.

9. KURZROK, R. Endocrines in Obstetrics and Gyne-cology. Pp. 80, 176, 191. Baltimore, 1937. Williams and Wilkins Co.

10. MARANON, G., RICHET, C., PERGOLA, A. and LESUEUR, G. La tetanie, secondaire a l'hyper-folliculineme. *Ann. d'endocrinol.*, 1: 142, 1939.

11. MARLOW, H. W. and KOCH, F. C. The effect of sex hormones on blood calcium and inorganic blood phosphate levels. *Endocrinology*, 21: 72, 1937.

12. MATHIEU, F. and BARNES, O. The effects of theelin and theelol in latent tetany. *Am. J. Physiol.*, 105: 172, 1933.

13. McCULLAGH, E. P. and KEARNS, J. E. The relation-ship between the parathyroid glands and sex hormones in tetany. *Endocrinology*, 19: 532, 1935.

14. PFEIFER, C. A. and GARDNER, W. U. Skeletal changes and blood serum calcium level in pigeons receiving estrogens. *Endocrinology*, 23: 485, 1938.

15. SPINGARN, C. L. and GEIST, S. H. Hyperparathy-roidism and pregnancy. *J. A. M. A.*, 113: 2387, 1939.

16. SWINTON, N. W. Postoperative parathyroid tetany. *New England J. M.*, 217: 165, 1937.

17. TODD, J. C. and SANFORD, A. H. Clinical Diagnosis by Laboratory Methods. Philadelphia, 1937. W. B. Saunders Co.

18. ZONDEK, H. The Diseases of the Endocrine Glands. Baltimore, 1932. William Wood & Co.
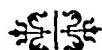
LYING as the toxic nodular goiter does, between the colloid goiter on the one hand and the degenerated cardiotoxic goiter on the other, the diagnosis must determine whether there is thyroid toxicity in the one instance, and an absence of general constitutional changes, notably cardiac insufficiency, in the other.

From—"Diseases of the Thyroid Gland. Presenting the Experience of More Than Forty Years"—by Arthur E. Hertzler (Paul B. Hoeber, Inc.).

POSTPARTUM APPENDICITIS[*]

REPORT OF TWO CASES

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APPENDICITIS during pregnancy has received much attention from the obstetrical world during the last twenty years so that its frequency, diagnosis and treatment is well known. On the other hand appendicitis having its onset during the puerperium has had little or no consideration. While undoubtedly an uncommon complication, it is such a serious one it must not be overlooked.

Babler,[1] in 1908, reported twenty-eight puerperal cases in his collective series of appendicitis associated with pregnancy and Findley,[2] in 1912, mentioned three cases. Since 1912, however, the English literature has been barren on the subject except for a case report of Sellers[3] in which he described a ruptured appendix discovered at operation on the fourth postpartum day. The foreign literature has been more productive. Jerlov[4] collected thirty-five cases from seventeen general hospitals and four lying-in hospitals in Sweden between 1900 and 1920. Fatyol[5] found only one such complication in 26,000 deliveries at the Toeth Gynecological clinic of Budapest. Marmasse[6] described a case of a gravida 1 who had a thirty-six hour labor terminated by forceps and who developed right lower quadrant pain thirty-six hours after delivery. A ruptured appendix was discovered seventy-two hours after the onset. Schulz[7] wrote of a similar case from the University Clinic which had its onset a few hours after delivery and in whom a suppurative appendix was found thirty-six hours later. Marmasse and Schulz discussed the diagnostic features involved, but the majority of the reports merely mentioned this condition as an entity which occasionally may be encountered.

It is evident from the above reports that appendicitis occurring in the puerperium is rare. Most cases were diagnosed late or not at all, hence the disastrous delay resulted in a high incidence of appendiceal rupture and general peritonitis. The following two cases are presented because they probably illustrate most of the diagnostic problems involved. A possible common etiological factor also was observed. They represent the only cases of acute appendicitis diagnosed in the puerperium in 17,489 deliveries at the Swedish Covenant Hospital of Chicago (a general hospital) from 1916 to 1939 inclusive.

CASE REPORTS

CASE 1. Mrs. J. W.. age twenty-nine, gravida 11 was admitted June 21, 1939 in labor. Her past history was negative for serious illnesses. The prenatal course was normal except for a mild attack of pyelitis in the fourth month. This cleared up promptly on urotropin and sodium acid phosphate. She was delivered spontaneously of a 9 pound 10 1/2 oz. male infant after eighteen hours of labor. Temperature and pulse were normal; hemaglobin, 90 per cent, red blood cells, 4,200,000, white blood cells, 11,000. The puerperium was uneventful until after an ounce of oleum racini was given on the morning of the third day. She had three bowel movements during the afternoon. About 9 P.M. she began to complain of mild cramp-like pains in the epigastrium and vomiting occurred once at 2 A.M. The pain became stronger and constant and by morning had localized in the right flank and lower right quadrant. At 9:30 A.M. her temperature was 101.4°F. (rectal), pulse 100, white blood count, 13,800. A catheterized urine specimen showed no white blood cells. The abdomen was flat. The uterus was 8 cm. above the symphasis and not tender to move-

ment. There was no adnexal tenderness. The lochia appeared normal.

There was marked tenderness high in the right quadrant, but no rigidity. The kidney was not tender. Diagnosis: Acute appendicitis. A consultation with a urologist and a general surgeon was held, both of whom agreed with the diagnosis, although a perinephritis was considered because of the previous history of pyelitis. The patient was observed for six hours during which time the pain increased and rigidity appeared in the right flank. The white blood count rose to 17,000.

Operation was performed June 25, 1939 at 6 P.M., twenty-one hours after the onset. A large dark red and fibrin-covered appendix was found retrocecal, bound down with firm adhesions. It was removed and the abdomen closed with drainage. Pathological diagnosis: "Acute suppurative hemorrhagic appendicitis." The postoperative course was uneventful; the drain was removed on the fourth day and the patient was discharged on the twelfth postoperative day with the wound healed.

CASE II. Mrs. F., age twenty-seven, gravida III was admitted in labor September 15, 1929. Her prenatal course had been normal and there was no history of previous attacks of appendicitis. She was delivered of a 7 pound infant after an eight hour labor. The puerperium was normal and afebrile for eight days when she received 1 dr. of caseara twice for constipation. During the following day she complained of mild cramps in the lower right quadrant, but had no bowel movement. Her temperature was 100.6°F. in the evening. On September 25, 1929 the temperature remained about 101°F., the pain remaining mild but becoming localized to a spot 5 cm. medial and 5 cm. above the right iliac crest. The following day the pain had become very severe and rigidity had developed over the lower right quadrant. The white blood count was 23,900 and the temperature had risen to 103.6°(R).

Operation was performed under ethylene anesthesia at 3 P.M. September 26, 1929, fifty-four hours after the onset of symptoms. An unruptured, retrocecal, gangrenous appendix was found. The appendix was removed and the abdomen closed with drainage. The temperature returned to normal on the tenth postoperative day and the patient was discharged on the sixteenth postoperative day with slight drainage from the abdominal wound.

ETIOLOGICAL FACTORS

Neither patient gave a history of previous attacks of appendicitis although both evidently had had trouble as evidenced by the dense adhesions found at operation. The attack of pyelitis experienced by the first patient early in pregnancy may well have been a mild attack of appendicitis. The high incidence of previous appendiceal pathology when the disease complicates pregnancy is a common observation. Our findings in these two cases would lead one to believe that this is equally true in puerperal cases.

Another common factor was noted: Both patients received a strong cathartic a few hours before the onset of symptoms, the first patient as a matter of routine and the second because of constipation. It is very suggestive that the resulting strong peristalsis flared up a slumbering infection of the appendix.

DIAGNOSIS

The onset of symptoms in Case I was almost the classical picture of acute appendicitis. The pain began in the epigastrium and after a few hours localized to the right lower quadrant. Vomiting occurred only once. The onset in Case II was slower, but finally the pain and tenderness became severe and localized to the right lower quadrant. It was observed that the tenderness and rigidity was higher in the abdomen than usually is seen in appendicitis. The explanation can be made on an anatomical basis. Baer[8] demonstrated conclusively that the appendix is displaced upward after the third month of pregnancy, reaching as high as the iliac crest by the sixth month. It does not return to its normal position until ten to fourteen days after delivery.

This upward displacement of the appendix in the peritoneal cavity should also influence the patient's reaction to the infection. The temperature could be expected to be higher and the pain more severe than if the appendix had been a pelvic organ. The temperature in Case I

reached 101.4°F. and in Case II 103.6°F. which is higher than one usually encounters in acute, unruptured appendicitis. Both patients complained of more pain than in the average case and it was the severity of the pain as well as the higher location that was the main factor in ruling out early puerperal sepsis or pelvic thrombophlebitis. The pain in early puerperal infection is generally slow in onset and of a minor nature. The uterus is subinvoluted and tender to movement. When the parametria are involved, pain and tenderness is present deep in the groin. No uterine or adnexal tenderness was elicited in either patient. The lochia may provide a clue as to the true nature of the difficulty. Within forty-eight hours the lochia of an endometritis becomes serous, seropurulent, or foul smelling if the infection is saprophytic. The lochia of the patients in question remained normal. A flareup of a gonorrheal salpingitis seldom begins before the seventh day and the findings usually are limited to the pelvis. A positive history of previous infection would be significant here.

The laboratory provides little aid in this condition. The normal puerperal white blood count may vary from 9,000 to 25,000 so that the leucocytosis observed meant little although the increasing white blood count was believed to be of some significance. A negative catheterized or clean specimen should help to rule out pyelitis in the abscence of a previous history. When pyelitis has been present, pus in the urine is to be expected, but sudden absence of pus accompanied by pain may indicate an acute obstruction of a ureter. Such a differentiation had to be made in Case I. It was believed that the absence of pus with no kidney tenderness and the rapidly changing symptom complex were enough to rule out pyelitis.

TREATMENT

Little need be said about treatment. It differs not at all from that of acute appendicitis observed at any other time. One hesitates to subject a woman who has just delivered a baby to a laparotomy, but the consequences of too long a delay are probably more serious here than at any other time because of the changed anatomical relations and the possible weakened condition of the patient due to her labor. The difficulty in making the diagnosis is bound to cause some delay so that the incidence of rupture and consequent mortality will be higher. The fear of surgery should not further complicate an already complicated picture.

SUMMARY

The literature of postpartum appendicitis is reviewed and two cases occurring in the early puerperium are presented.

The outstanding features of these cases are discussed in relation to the differential diagnosis of some of the common complications of the early postpartum period, namely, pyelitis, early puerperal sepsis and salpingitis.

It is suggested that the cathartic given to both patients shortly before their onset of symptoms may have been an etiological factor.

The treatment recommended is surgery as soon as the diagnosis is made.

REFERENCES

1. BABLER, E. A. Perforative appendicitis complicating pregnancy. J. A. M. A., 51: 1310, 1908.
2. FINDLEY, P. Appendicitis complicating pregnancy. J. A. M. A., 59: 612, 1912.
3. SELLERS, N. E. Acute appendicitis during pregnancy and the puerperium. J. M. A. Alabama, 5: 18–191, 1935.
4. JERLOV, E. Appendicitis during pregnancy and puerperium. Acta obst. et gynec. Scandinar., 4: 6, 1925.
5. FATYOL, C. Acute appendicitis during the course of pregnancy. Orrosi betil., p. 166, 1934.
6. MARMASSE, J. Acute appendicitis as a sequela of labor. Presse méd., 38: 1122, 1930.
7. SCHULCZ, A. Acute appendicitis after childbirth. G1 ögy á szal, 73: 33–34, 1933.
8. BAER, J. Appendicitis in pregnancy. J. A. M. A., 98: 1359–1364, 1932.

REGIONAL ANESTHESIA FOR HIGH LIGATION OF THE INTERNAL SAPHENOUS VEIN

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LIGATION of the internal saphenous vein and its tributaries at the junction of the former with the femoral vein is a common procedure in the treatment of varicose veins of the lower extremity. Its value need not be defended here.

The operation is almost always performed under local anesthesia because the danger of embolism is minimized by moderate activity of the patient soon after the operation. Ochsner and Mahorner[1] state: "Simple ligation can be considered as being practically without danger if the patient is not allowed to remain in bed during the post-operative period."

Descriptions of the anesthesia for high ligation of the internal saphenous vein are usually limited to mere statements that local anesthesia or infiltration of the line of incision should be used..

The recognition[2] of the fact that the operation will fail if it is improperly or incompletely performed should focus attention on the best type of anesthesia to be used.

Labat[3] distinguished between regional anesthesia and local anesthesia. He stated: "Regional anesthesia is a result of a certain number of delicate surgical procedures by which it is possible to control pain temporarily by interrupting the sensory nerve conductivity of any region of the body. Motor function is occasionally interfered with. Regional anesthesia is best realized by injecting an anesthetic solution in the immediate vicinity of the nerves supplying the operative field. It is commonly called local anesthesia; but it differs from local anesthesia in that the anesthetic fluid is never injected along the line of

incision or within the structures of the surgical wound."

It is the purpose of this paper to call attention to a field block described by Labat for ligation of the internal saphenous vein at the fossa ovale. Personal experience with the method has verified its value. The anesthesia is complete; it permits a thorough painless exposure of the structures of the fossa ovale so necessary to the successful performance of the operation. The method is slightly more elaborate than infiltration of the line of incision but the quality of the resulting anesthesia is more satisfactory. Any one experienced in regional anesthesia knows that a field block is less painful than the method of injecting an anesthetic solution and operating until pain is experienced and then repeating the process one or more times.

METHOD

The anterior crural nerve is first blocked. A skin wheal is raised just below Poupart's ligament 1 cm. lateral to the femoral artery. With a finger holding the femoral artery medially, a needle 5 cm. long, unattached to the syringe, is introduced through the skin wheal in a direction perpendicular to the surface of the skin and advanced until the resistance offered by the fascia iliaca is overcome. The needle is then gently advanced about 1 cm. farther until paresthesias, which radiate toward the knee or inner side of the thigh or leg, are induced. Without moving the needle the syringe is connected and 5 cc. of a 2 per cent procaine hydrochloride solution containing adrenalin hydrochloride 1 : 100,000 are injected. It is hardly necessary to state that the solution is never

injected without first aspirating to determine that the point of the needle is not within the lumen of a blood vessel. If the point of the needle does not reach the nerve by the first puncture, the needle is partly withdrawn and its direction slightly changed outward, then inward, care being exercised to keep the finger on the femoral artery retracting it medially if necessary to protect it from the point of the needle. If paresthesias are not induced, the anesthetic solution is distributed fan-wise beneath the fascia iliaca.

Next the obturator nerve is injected. With the thigh slightly abducted the pubic spine is defined and a skin wheal raised just below and lateral to it. A needle 8 cm. in length, unattached to the syringe, is introduced through the skin wheal in a direction perpendicular to the skin surface and advanced toward the horizontal ramus of the pubis. When the needle impinges on the bone, it is partially withdrawn, its direction changed by inclining its shaft a little inward and downward, and reintroduced until its point again comes in contact with the bone. The upper wall of the obturator canal is then felt and the needle passed beneath it and advanced 2 cm. further, keeping close contact with the upper wall of the canal and following its direction outward, backward and upward. An injection is then made of 10 cc. of a 1 per cent solution of procaine hydrochloride containing adren-

alin hydrochloride 1:100,000 while the needle is slightly moved to distribute the solution along the obturator canal. Paresthesias are exceptionally induced during these manipulations, anesthesia being secured by diffusion of the solution in the connective tissue in which the nerve is imbedded.

A skin wheal is now raised at the apex of Scarpa's triangle. Intradermal and subcutaneous injections are now made from this wheal along the sartorius and adductor longus muscle up to Poupart's ligament and along the ligament. These injections require about 60 cc. of a 0.5 per cent procaine hydrochloride solution containing adrenalin hydrochloride 1:100,000.

SUMMARY

Attention is called to Labat's field block for ligation of the internal saphenous vein and its tributaries at the fossa ovale. This field block is superior to haphazard infiltration anesthesia; it permits a perfect painless exposure of the structures involved, so necessary to the successful performance of the operation.

REFERENCES

1. OCHSNER, ALTON and MAHORNER, HOWARD. Varicose Veins. P. 106. St. Louis, 1939. C. V. Mosby Company.
2. STALKER, L. K. and HEYERDALE, W. W. Factors in recurrence of varicosities following treatment. *Surg., Gynec. & Obst.*, 71: 723, 1940.
3. LABAT, GASTON. Regional Anesthesia. P. 1. Philadelphia, 1923. W. B. Saunders Company.

Case Reports

STAB WOUND OF THE HEART*

REPORT OF TWO CASES IN WHICH SUTURING WAS SUCCESSFUL

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SINCE the first successful cardiorraphy by Rehn[1] in 1896, the literature has revealed an ever increasing number of cases in which successful suture of the heart has been performed. The report of such a case is, therefore, no longer a novelty. However, a recording of these cases with an analysis of the factors involved gives the surgeon invaluable material for study. In this way, principles and procedures may be elaborated to render the incidence of success higher. With this in mind, these two cases are presented. They are consecutive and have been handled in the same manner:

CASE REPORTS

Case 1. J. H., colored male, aged forty-five years, came to Harlem Hospital by taxicab and was admitted at 12:40 a.m. April 19, 1938, with a history of stab wound of the left chest inflicted thirty minutes previously. On admission the patient was conscious and oriented but in severe shock with pulse absent and blood pressure not obtainable. Diagnosis was made of stab wound of the heart with pericardial tamponade and left hemopneumothorax. On the way to the operating room a chest x-ray was taken. No stimulants were given but morphine sulfate, gr. ¼, was administered and preparations were made to give at the appropriate time saline infusion and a blood transfusion.

Clinical examination revealed two stab wounds of left chest: (1) A one-inch stab wound below the junction of the inner and middle third of the clavicle, running downward and penetrating the second interspace just outside the left border of the sternum. This was a sucking wound. There was no crepitation in the soft tissues about or around the wound. (2) A one-inch wound one inch above and just medial to the left nipple, coursing down and medialward, severing the fifth costal cartilage one-half inch from the sternal border. From this wound there issued a continuous flow of dark red blood.

It was estimated that operation was performed about one and one-half hours after infliction of the wounds. General anesthesia (ether) was given. A skin incision was made along the left sternal border to the fourth interspace, then curved outward and downward to and about one and one-half inches below the nipple. Carrying the skin incision down to rib cartilage, a skin-fascia-muscle flap was dissected up, exposing the cartilages of the fourth and fifth ribs. The cartilage of the fifth rib was seen to be severed. The fourth and fifth cartilages and about one inch of both ribs beyond the costochondral junction were removed. As soon as the chest was opened, the collapsed left lung was seized by sponge forceps and held firmly so as to stabilize the mediastinum. This was the old device Müller[2] used to combat the immediate ill effects of an open pneumothorax.

The pericardium was greatly distended and blood flowed freely from a one and one-half inch wound on the anterior surface. This wound was enlarged in the axis of the heart in

order to obtain adequate exposure. Bleeding was profuse and there were few clots. On the anterior surface of the heart, apparently the

the closure was now airtight. Suture of the fascia-muscle flap was done and then the skin closed making closure of the chest as airtight

FIG. 1. J. H., operated upon April 19, 1938; picture taken June, 1938, two months postoperatively.

FIG. 2. J. H., operated upon April 19, 1938; x-ray taken January, 1941, two years and nine months postoperatively. Patient sustained stab wound of heart.

right ventricle, was a wound about three-quarters of an inch and at right angles to the long axis of the heart from which dark red blood gushed with each systole The rhythm of the heart was irregular and could be appropriately termed "a crazy, fluttery" rhythm. Two Allis clamps applied to the wound edges brought them together and gave temporary closure. Three figure-of-eight sutures of fine silk, tied with the heart in systole, closed the wound; almost immediately, the arrhythmia ceased and there was no further bleeding from the heart. The posterior aspect of the heart was inspected and found intact.

There seemed to be about 300 cc. of blood in the pleural cavity and the same amount in the pericardial sac. As much as possible of this was removed manually and by suction but a small quantity was left in the pleural sac. The pericardium, after all bleeding points were secured along its cut margins, was left open widely. Hemostasis was of obvious importance because, as the patient reacted favorably, bleeding increased along the lips of the pericardial wound. The lung was marsupialized (extrapleuralized), suturing it to the periphery of the thoracotomy wound. This anchored the lung and gave mediastinal stabilization. The upper and lower lobes of the lung were then sutured together at that part of the interlobar fissure which presented in the extrapleuralized portion of the lung. For all practical purposes

as possible. A wick of iodoform gauze was packed in the lower stab wound. The upper stab wound, a sucking wound, was closed tightly by suture. Underwater drainage was established in the midaxillary line in the third left interspace.

Immediately following suture of the heart wound, an infusion had been started. This was subsequently replaced by a transfusion of 500 cc. of citrated blood.

On his return to the ward, an oxygen tent was used. Because of difficulty in reaching the patient for clinical observation and therapy, it was discarded within twelve hours in favor of nasal catheter and mask. This facilitated closer observation, more effective treatment and nursing. Oxygen was given in this manner during the first three weeks. Underwater drainage was maintained for three days. During the first day, the patient gave evidence of increasing respiratory difficulty. At the same time it was observed that the underwater drainage had ceased to function and pneumothorax reading was definitely positive. The needle was removed and found to be clogged. It was cleaned, re-introduced and re-attached; air blew off, some fluid began to drain from the chest and the patient experienced great relief almost immediately. On the third day with no further drainage of air or fluid and with a normal pneumothorax reading, the needle was removed. Subsequently, re-establishment of

underwater drainage was never clinically indicated.

The blood pressure improved following operation and on the fourth day was stabilized at

nipple running down and medialward penetrating the thorax in the fourth intercostal space. This wound was definitely a sucking wound.
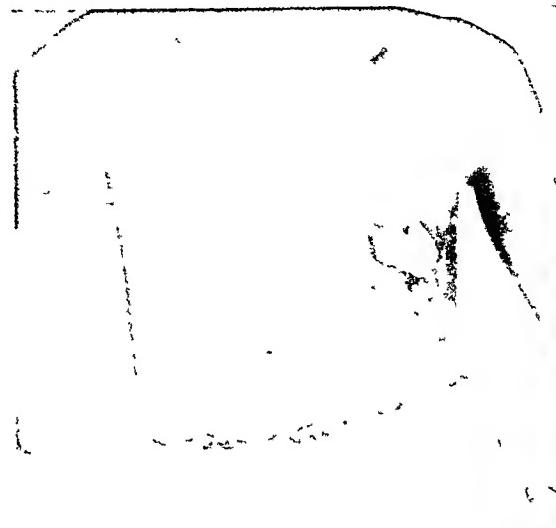
FIG. 3. N. S. Patient sustained stab wound of heart. He was operated upon in June, 1938. This picture was taken two months and ten days postoperatively.

FIG. 4. N. S. This x-ray was taken January, 1941, two years and seven months after accident.

120/90. The pulse rate remained between 100 and 150 during the first two days and by the fourth day was 90. Thereafter, it varied little, never rising above 100. A moderate temperature of 100 to 101°F. during the first two weeks was associated with a massive pleural effusion, which did not become infected despite three tappings. Eventually, with resorption of this fluid and organization, the temperature came down to normal in seven weeks and remained so thereafter. The patient was discharged sixty-nine days after operation.

CASE II. N. S., a colored male, aged nineteen years, was admitted to Harlem Hospital at about 10:55 P.M., June 18, 1938, with a history of stab wound of the left chest inflicted fifteen minutes previously. On admission, the patient was conscious and oriented but apparently in great distress. He was dyspneic and cried out for the severity of the pain in his precordium. On reaching the ward, the patient experienced a short period of unconsciousness with a profuse and clammy sweat. His pulse was above 130 but of fair quality; his blood pressure was 130/80 at this time. He was ordered to the operating room immediately with a diagnosis of stab wound of the heart. On the way, a chest x-ray was taken.

Clinical examination revealed a one-inch stab wound just to the inner side of the left

It was estimated that operation was performed about one hour and twenty minutes after the stabbing. General anesthesia (ether) was used.

As with Case I, the chest was entered by the transpleural route. There was a wound about a half inch in length on the anterior surface of the pericardium toward the left border and apex; through this, blood gushed intermittently. This wound was enlarged in the axis of the heart giving full and adequate exposure. To the left of the interventricular sulcus and about an inch from the apex, was found an irregular wound about 1 cm. in length from which issued with each contraction of the heart, small jets of blood. Using an Allis clamp on either side of the wound for approximation and temporary closure, two figure-of-eight sutures, one No. o chromic, the other fine silk, were used to give an effective permanent closure. There was still profuse bleeding, however, prompting further investigation. A second myocardial wound was discovered a quarter inch to the right of the interventricular sulcus and close to the diaphragmatic border. One figure-of-eight suture of fine silk did not effectually close this wound, so it was supplemented by another. The case was handled subsequently in the same manner as Case I, with pericardium left widely open and extra-

pleuralization of the lung to the periphery of the thoracotomy wound. At the operating table it was decided that the upper or the wound in the left ventricle could be considered the wound of entrance and the lower or wound of the right ventricle was the wound of exit. Surprisingly, the diaphragm was not injured. There was about 500 cc. of blood in the pleura and about 200 cc. in the pericardial sac. Remembering the morbidity, incident to a sizable quantity of blood left in the pleura in Case 1, all blood, fluid and clotted, was removed as completely as possible.

Following operation, the patient became extremely restless, noisy and violent to a rather alarming degree. Morphine was ineffective but pantopon was highly efficacious as a sedative. Narcotics were unnecessary after two days. Thereafter the course was uneventful and uncomplicated. The patient was out of bed on the fourteenth day and discharged July 12, 1938, twenty-five days after operation.

COMMENT

In both cases, the pericardial wounds were situated above and were larger than the wounds in the myocardium. Such a physical arrangement, a valve-like affair, interfering with a free and complete egress of blood from the pericardium, incarcerates blood in the pericardial sac, preventing a vital blood loss in the pleural cavity or to the outside through the parietal wound. Thus, there is developed what has been called pericardial tamponade,[3] a compression which is as necessary for the immediate survival of the patient from acute hemorrhage as it is inevitably fatal if this compression is unrelieved in due time. In both cases, tamponade developed and existed about one and one-half hours without fatal consequence. This, we think, is a significant observation.

After closure of the myocardial wound all other bleeding must be thoroughly controlled, bleeding from the cut pericardium, lacerated lung, the vessels of the parietes, the internal mammary and the intercostal vessels.

Despite the fact that airtight closure may be effected after suture of the thoracic wound, and despite stabilization of the mediastinum by fixation of the lung to the parietes, the pneumothorax which is present in the left chest may persist or may increase to produce a tension pneumothorax. Such a tension pneumothorax may, through compression, decrease the vital capacity not only of the left but of the right lung and bring about exitus. Underwater drainage should, therefore, be instituted in all cases both for therapeusis and prophylaxis. A needle with practically no bevel and of adequate bore is desirable. Drainage should be checked frequently to be certain of the mechanical integrity of the device. If the needle is ineffective because it becomes clogged or abuts on lung surface, intercostal tube drainage should be established. A fairly large sized stiff tube (definitely not a catheter) should be used.

The removal of all blood from the pleural cavity unquestionably influences the morbidity. This was strikingly illustrated by the second case in which blood and clots were completely removed from the chest.

In both cases, the phase of acute cardiac reaction incident to trauma and repair (manifested by an extremely rapid and irregular pulse) did not last beyond the third day.

The transpleural approach employed is recommended because it gives direct, quick and easy access to the pathological condition. It is certainly desirable in those cases in which the wound has traversed the left pleural cavity, with the existence of an open pneumothorax as is the case in sucking wounds.

Silk sutures are recommended but fine chromic catgut may be satisfactorily used.

Sulfanilamide was used in both cases during the first week and in the first case for at least two weeks. This is recorded as a matter of fact. It is obviously impossible to speak with any conviction as to its influence in either case.

CONCLUSIONS

In conclusion, one may feel certain that the successful suture of a heart wound will depend on: (1) *The location and size of the*

wound and the nature of the heart muscle. I mention this last factor because I have seen a stab wound in the heart muscle of almost jelly-like consistency in which sutures could not be successfully applied, resulting in death on the operating table. (2) *Associated injuries:* laceration of great vessels, laceration of internal mammary artery, etc. A wound of the right chest, sucking in nature, producing a pneumothorax on the right side, may cause immediate fatal results, if not instantly recognized and treated by closure and drainage for decompression. Associated injuries in other parts of the body, abdomen and extremities, may alter prognosis. (3) *Thorough parietal hemo-* stasis. (4) *Control of pathologic physiology:* tension pneumothorax and lung fixation (mediastinal stabilization). This latter is desirable but not imperative when positive pressure anesthesia is employed. (5) *Infection:* Prophylaxis—(a) Open pericardium; (b) minimum blood and clots in the thoracic cavity; (c) the use of sulfanilamide.

REFERENCES

1. GRAHAM, SINGER and BALLON. Surgical Diseases of the Chest. P. 309. Philadelphia, 1935. Lea & Febiger.
2. SAUERBRUCH and O'SHAUGHNESSY. Thoracic Surgery. P. 24. Baltimore, 1937. William Wood & Co.
3. ROSE, E. Herztamponade. *Deutsche Ztschr. f. Chir.,* 20: 329, 1884.
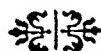
It is nearly always a serious mistake to administer an anodyne to relieve pain caused by a splint.

From—"A Manual of the Treatment of Fractures"—by John A. Caldwell (Charles C. Thomas).

THE EXPERIMENTAL SCLEROSIS OF THE GALLBLADDER*

PRELIMINARY REPORT

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SURGERY of the biliary tract is the second most common operation performed in general practice. A study of the morbidity and mortality rates shows that the average mortality of cholecystectomy is approximately 10 to 15 per cent.[1,2] There are two reasons for this: (1) *the immediate causes:* e.g., peritonitis, hemorrhage, pulmonary complications, heart disease and so-called shock; and (2) the *predisposing causes:* e.g., insufficient preoperative care and the inexperience of the surgeon in the anatomical, physiological, pathological and surgical aspects of biliary tract disease. The former are partially controllable, the latter are less so.

For the sake of discussion it can be agreed that the following statements are true: (1) Peritonitis (infective or chemical) may be the result of a ligature slipping off the cystic duct, or it may follow bile seepage from the liver; (2) hemorrhage can occur if the cystic artery ligature slips off, if the artery is not tied or if "oozing" is profuse from the liver bed; (3) lung complications are more likely to follow surgery which hinders normal postoperative respiration (traumatizing procedures in the upper abdomen); (4) heart complications may be precipitated by a long anesthetic (anoxemia), a long operation, pneumonia, etc.; (5) shock is increased by "manhandling" vital structures, a long anesthesia and a long operation.

On this basis it seemed logical to formulate the following hypothesis: If the gallbladder could be removed from the digestive tract without incurring the above potential dangers, it might be possible to lower the mortality and morbidity rates without increasing the incidence of unfavourable postoperative results. In other words, if the gallbladder could be removed without cutting the cystic duct, there would be less chance of either an infective or a bile peritonitis, without cutting the cystic artery there would be less chance of hemorrhage, and without removing the gallbladder from the liver bed there would be less chance of hemorrhage, infection or bile seepage. If all this could be accomplished by a short, simple and safe procedure, the time required for the operation would be lessened, the quantity of anesthetic would be thus reduced and the operation shock minimized. These latter factors would serve to decrease liver damage as well as the possibilities of heart and lung complications. A combination of all should lower the incidence of the causes of death.

The hypothesis was tested experimentally and encouraging results were obtained. Since the idea of sclerosing the gallbladder is new, the findings open a new field for investigation which may prove a justification for publishing this incompleted work.

EXPERIMENTAL PROCEDURES

For the sake of brevity the procedures and results will be noted only in so far as they influence the conclusions.

Tying the Cystic Artery. The idea of sclerosing the gallbladder by reducing the

blood supply was born when a sclerosed ovary was found as the result of its blood supply having been severed at a previous

Sodium Morrubate, Etc.). The results in this group were also unsatisfactory. They showed that the blood supply must be
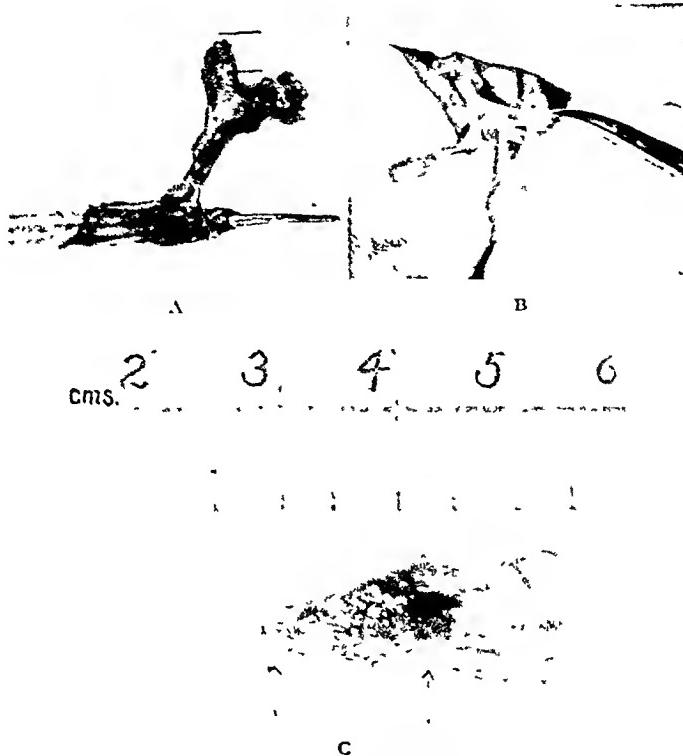

FIG. 1. Photographs of three sclerosed bladders. A, probe in common duct from which the cystic duct leads to the sclerosed gallbladder. A small piece of liver has also been removed and lies next to the rule. The bladder measures 6 mm. in length; injected for eight months. B, photograph six months after sclerosing. The bladder and cystic duct are on the left. A "tooth-pick" through the common duct and the ampulla are seen on the right. c, shows patent cystic duct with small match in it and the sclerosed bladder attached to the liver (distal). This gallbladder (between the arrows) measures a little over 1 cm. in length; injected four months.

operation. Six dogs were operated upon. In only two did the gallbladder become smaller as shown by latter operations; two died of peritonitis due to perforation and in two the bladder was distended, thickened and showed areas of early necrosis. The results were unsatisfactory from the standpoint of sclerosis, but are of great interest because four gallbladders did not perforate even though their blood supply was lost (two were gangrenous). This procedure is too traumatizing to have clinical application.

Tying Both Artery and Duct and Filling the Empty Bladder with Different Sclerosing Agents (50 *Per Cent Glucose, Quinine,*

left intact. Only three of the eleven dogs operated upon showed sclerosis and four died of gangrene. The higher incidence of gangrene in this group, as compared with the first, may be due to the handling of the bladder which was necessary when it was injected.

Tying the Duct and Filling the Empty Bladder with Sclerosing Agents. Five of twelve dogs showed, after a period varying from four to six months, a smaller gallbladder, but there were still both macroscopic and microscopic signs of necrosis.

Tying the Duct, Removing the Bile and Washing out the Empty Bladder with Bile Acid Solvents—Then Washing out the Clean

Bladder with Sclerosing Agents and Leaving the Walls in Apposition. The pathological condition resulting from the experimental bile. It seemed, therefore, that if these could be removed at least one provoking cause of a pathological change (particu-
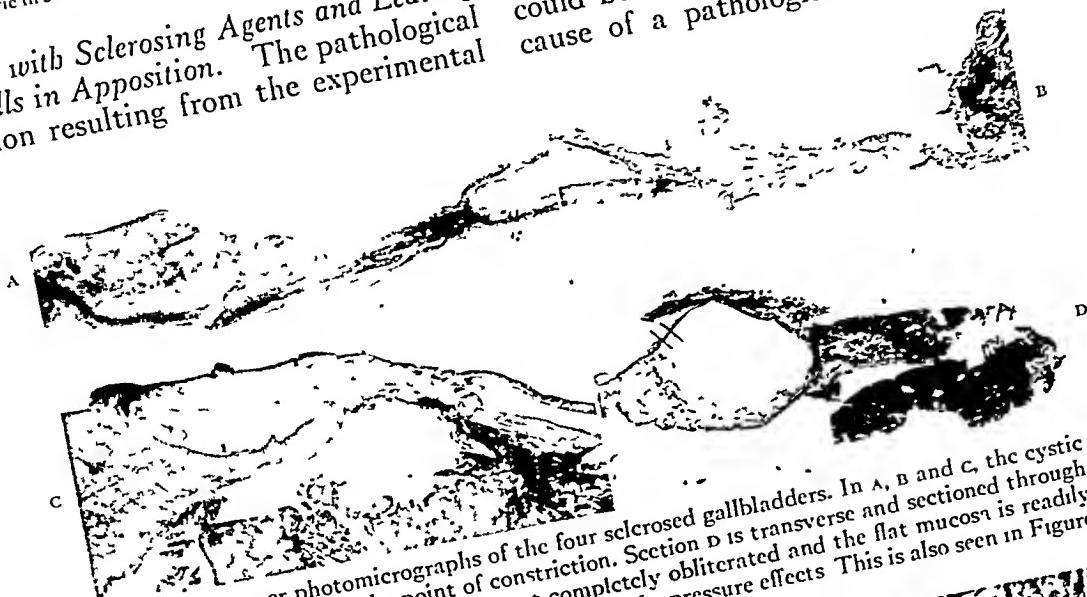
FIG. 2. Low power photomicrographs of the four sclerosed gallbladders. In A, B and C, the cystic duct is plainly seen at the point of constriction. Section D is transverse and sectioned through the center. In C and D the cavity is not completely obliterated and the flat mucosa is readily seen. In C is shown one villus which has escaped the pressure effects This is also seen in Figure 3D.

FIG. 3. High power sections of sclerosed bladder wall. A, B and C show the new fibrous tissue. No sign of acute inflammatory reaction can be seen. In C and D the flat epithelium is shown and in D the one villus (Fig. 2C) which has escaped pressure. (How often is such a villus the nidus of a stone?)

ligation of the cystic duct is often due, apparently, to the *toxic* and necrosing effects of the bile acids in the gallbladder larly gangrene) would be eliminated. This was done after the cystic duct had been securely tied (catgut, linen, silk) by with-

drawing all bile from the bladder and cleaning the interior through the same needle with a strong solvent of bile acids (e.g., a 5 per cent aqueous solution of sodium carbonate). This left the bladder as a thoroughly clean and closed bag with a normal blood supply. The same sclerosing agent, opturatin,* was used in all dogs in this series. It was injected into the bladder while the needle was still in place, left in contact with the walls for a few minutes and withdrawn. This withdrawal collapses the walls so that the mucosal surfaces, moistened with the sclerosing agent, are left in contact with each other.

Six dogs were operated upon and two were re-operated upon, one ten days and the other fourteen days after sclerosing. They showed that the immediate reaction is a mucosal secretion with the formation of a mucocele. The end result in the remaining four was a sclerosed gallbladder averaging approximately 1 cm. in size. These are illustrated in the accompanying figures. No ill effects were noticed in any of the animals even though three had previously had experimental ligation of a coronary artery with a resulting infarct, as shown in the electrocardiographs. This is evidence that the procedure is not excessively dangerous and indicates that this is the only safe method of experimental sclerosis so far attempted.

DISCUSSION

These experiments upon dogs have indicated that it is possible, in that species at least, to remove the gallbladder as a functional unit (i.e., physiological removal) without the extensive manipulations attendant upon surgical removal. The simplification of the operative procedure greatly

reduces the complications which are frequent sequelae of the conventional methods of gallbladder surgery. The finding that the normal gallbladder in dogs can be sclerosed without any remaining inflammatory signs and without damage to the liver is suggestive and presents certain points for clinical consideration.

It would be hasty to conclude from the results presented here that a diseased human gallbladder could be treated in the same way with equally satisfactory results. Even if such a procedure should prove suitable for clinical application it would not necessarily be always the method of choice; no surgical procedure is ever used to the exclusion of all others. Such application would have to be established by a carefully controlled series of patients. Much experimental and clinical work remains to be done but it is hoped that this preliminary communication will at least initiate further work, and thus point the way to possible improvements in the proposed treatment and elimination of many of the potential complications at present associated with cholecystectomy.

REFERENCES

1. MACDONALD, DEAN. A practical and clinical test for liver reserve. Surg., Gynec. & Obst., 69: 70–82, 1939.
2. MACDONALD, DEAN. The gallbladder problem in general practice. Canad. M. & S. A. J., 45: 29–36, 1941.

* At the time this work was done Dr. Hall was Associate Professor of Medical Research. He is now in charge of the Medical Research Division of the Royal Canadian Air Force. Dr. Janes is now a medical officer in the Royal Canadian Air Force.

* Opturatin is a sclerosing agent composed of zinc sulfate, phenol, glycerin, cinnamon water, F. E. pinus canadensis and distilled water.
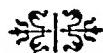
PARAFFINOMA OF THE NOSE*

CASE REPORT

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PARAFFINOMA was frequently encountered during the first quarter of the present century but now this lesion, with the exception of pulmonary paraffinoma, has become quite a curiosity.

In this country, Hunt,[1] in 1924, reported one hundred cases of paraffinoma encountered during twenty years of his own practice, although from 1920 to 1940 the entire literature shows a total of seventy-nine papers, two-thirds of which were published abroad. Moreover, many of the cases reported in the American literature did not originate here, but were the results of injections performed in various European countries for the purpose of evading military service.

Lipoid pneumonia of the adult type, caused by aspiration of mineral oil into the lungs, is considered a true paraffinoma of the lung. Unfortunately, the incidence of this lesion is on the increase. Ikeda,[2] in 1937, found 106 cases of lipoid pneumonia recorded in the literature from 1925 to 1936. Of these, 64.1 per cent were in infants and children, and 35.9 in adults. Among these adults, 39.5 per cent showed a true lipoid pneumonia of the adult type, the pathology of which Ikeda describes as a true paraffinoma. To these he adds seven cases of lipoid pneumonia in a series of 107 consecutive necropsies of infants, in a period of three years. He has since collected five instances of lipoid pneumonia in adults.

According to Davis,[3] paraffinoma is a "chronic inflammatory process involving skin and adjacent subcutaneous tissues characterized clinically by the development of reddish purple indurated masses, painless, not tender, persistent, not subject to ulceration and, as a rule, ordinarily benign." In the opinion of the same author there must be a special disposition to the formation of paraffinoma, since not all patients who receive paraffin injections necessarily develop tumors. Though usually benign, cases of malignancy attributed to paraffin injections have been reported.

As a rule, after an initial inflammatory reaction of short duration following the injection, the paraffin is surrounded by a thick layer of fibroblasts and may remain a quiescent foreign body for a long time. Occasionally, after a period varying from several weeks to many years (ten years in the case here reported), a secondary reaction may supervene which results in the production of an extensive cellular infiltration and fragmentation of the oily mass. The end result is the elaboration of the characteristic neoplasm which has been designated "paraffinoma."

The suggestion has been made by Johnson[4] that allergy may play a rôle in the secondary reaction leading to tumor formation. Trauma is another factor which frequently precipitates the cellular response.

I consider this neoplasm sufficiently rare at the present time to warrant a detailed report. In addition, a revised method of correcting the nasal deformity is described in detail.

CASE REPORT

H. G., aged forty, male, merchant by occupation, presented himself with the following history: Some twenty years previously, following a submucous resection, he sustained a falling of the bridge of the nose. About a month

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after this accident, the same surgeon who had operated upon him injected paraffin to obliterate the disfigurement. The patient suffered no

anesthesia an incision 32 mm. in length was made extending from the root to almost the tip of the nose. Under careful dissection the tumor

FIG. I. A, front view before operation; B, profile before operation.

FIG. 2. Photograph of tumor removed.

immediate ill effects from the injection until about ten years ago, when he noticed a gradual tumefaction around the bridge of the nose which gradually grew until it reached its present size, about that of a hazel nut. Examination revealed a tumor of the bridge of the nose, extending from the tip to the root and also spreading laterally. It was markedly adherent to the skin, which presented a purplish and reddish appearance but showed no inflammatory reaction. At the center of the nose there was a slight protuberance the size of a small pea, which showed some tendency toward breaking down. (Fig. I.) The blood Wassermann test was negative. On November 19, 1940, he was hospitalized, and under local

was removed; it weighed 4½ Gm., was 36 mm. long, 25 mm. wide at the center and 15 mm. thick. (Fig. 2.) The cut edges of the skin were sutured with fine silk material. The sutures were kept in situ for twenty-four hours and then removed. For the purpose of correcting the saddle nose deformity to be expected after the removal of the tumor, the standard technic employed for the purpose of narrowing the bridge of the nose was as follows:[5] Incisions were made at the extreme lower end of the pyriformis opening of both sides of the nose. The periosteum was freed from the bone, from the lower external end of the pyriformis opening to the radix nasi, and the bone sawed with a knee-shaped Joseph saw through the proc-

essus frontalis of the maxilla on both sides. The freed portions of the bones were pushed toward the median line for the purpose of narrowing the

paraffinoma, the cavity be filled with areolar tissue; he also advises the removal of sections of the stretched skin.

FIG. 3. A, front view after operation; B, profile after operation.
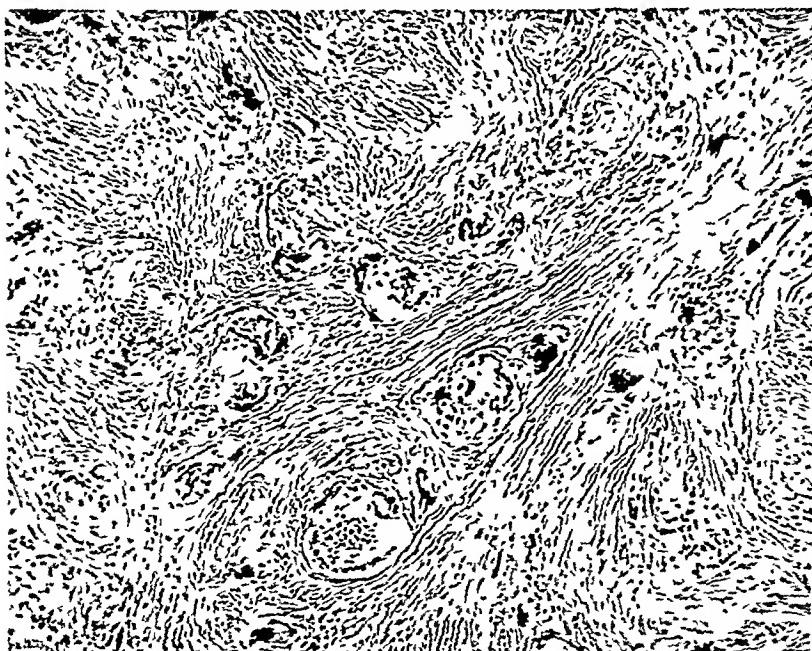
FIG. 4. Photomicrograph of specimen removed showing a mass of fibrous tissues in which there are innumerable foreign body giant cells containing and surrounding elongated and oval-shaped spaces.

bridge of the nose. The fractured bone was then held in place by a lead splint for one week. Hunt[1] recommends that after removing the

My results in this case have been extremely gratifying. The patient was left with a barely noticeable thin linear scar and otherwise good

cosmetic results. This method is therefore recommended to the profession for the treatment of similar cases. (Fig. 3.)

The pathologic report was as follows: There are a mass of fibrous tissues in which there are innumerable foreign body giant cells containing and surrounding elongated and oval-shaped spaces. These clear spaces are also found in the scar tissue apart from the giant cells. *Diagnosis:* Foreign body granuloma, paraffinoma. (Fig. 4.)

SUMMARY

A case of paraffinoma of the nose is herewith presented. The literature is discussed and the methods employed for the removal of the neoplasm, and the correction of the deformity are described in detail.

REFERENCES

1. HUNT, H. L. Conclusions from one hundred cases of paraffinoma. *Med. Times*, 52: 145–148, 1924.
2. IKEDA, K. Lipoid pneumonia of the adult type (paraffinoma of the lung): report of five cases. *Arch. Path.*, 23: 470–492, 1937.
3. DAVIS, B. F. Paraffin cancer. *J. A. M. A.*, 62: 1716, 1914; Ibid: Paraffinoma, wax cancer. *J. A. M. A.*, 75: 1709, 1920.
4. JOHNSON, P. E. Paraffinoma of the knee. A case report. *West. J. Surg.*, 45: 331–333, 1937.
5. WOLF, G. D. Rhinoplasty: facts and fiction. *Arch. Otolaryngol.*, 11: 322–333, 1930; Ibid: Correction of saddle nose. *Arch. Otolaryngol.*, 22: 304–311, 1935.
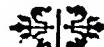
THE point is not always kept in mind that ordinary infections if local and well drained stimulate osteogenesis. This formation of bone in the vicinity of an infected fracture may be useful if all the parts are in correct position and if the wound is kept open so that deep abscesses are not enclosed in the healing bony or connective tissue scar.
From—"Wounds and Fractures"—by H. Winnett Orr (Charles C. Thomas).

INCARCERATED PELVIC KIDNEY EXHIBITING UNUSUAL FEATURES

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ALTHOUGH urologic literature abounds in cases of aberrant renal vessels, and many of these vessels
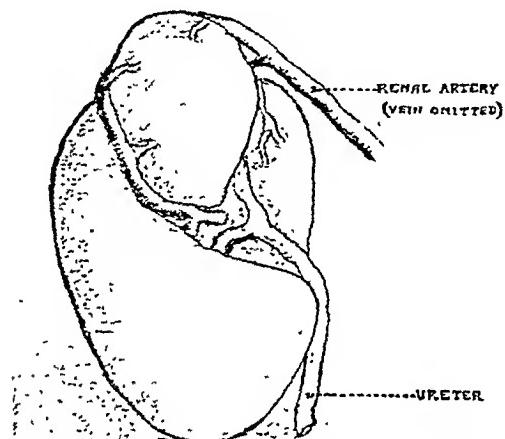

FIG. 1. Showing incarceration of kidney by surrounding vessels.

exhibit unusual courses to upper as well as to lower kidney poles, it is unusual for the main renal vessels to encircle the kidney. The accompanying drawing illustrates such a case which may have interest in this connection.

Another oft-stated dictum, that pain in ectopic kidneys is never present unless accompanied by pelvic dilatation or hydronephrosis, would also seem to be refuted by this same case, in that no dilatation was in evidence.

CASE REPORT

A young woman of twenty-six came to us with a complaint of persistent pain in the right lower portion of her abdomen, corresponding with a palpable tumor lying on the promontory of the sacrum, slightly to the right of the midline. The mass allowed of some lateral motion, but resisted longitudinal displacement, upward pressure against the tumor exaggerating her pain.

Because of the need for pelvic exploration also, a transperitoneal approach to the tumor was made, and a somewhat small kidney, incarcerated by encirclement of the upper pole by the main renal vessels, was found. Tension from the encircling vessels had caused rotation of the organ in all three planes, the pelvis facing forward, and the lower pole being disposed anteriorly and laterally. Since the ureter exhibited seemingly unused length and pain was the paramount symptom necessitating relief, it was thought that freeing the kidney from the incarcerating vessels and doing a nephropexy of some sort afforded the only chance of relieving the patient.

While attempting to slip the vessels out of the groove they occupied, and up over the upper pole, several small vessels which entered the kidney substance directly, were encountered. These were ligated, but two escaped and retracted, and caused considerable hemorrhage which could not be controlled by any of the usual methods.

The danger of persistent postoperative hemorrhage, as well as fear of possibly too great encroachment upon the lumen of the main renal artery by the many ligatures required immediately adjacent to it, caused a nephrectomy to seem to be the part of wisdom, the other kidney being normal in position and function. The convalescence was uneventful, and the patient's pain was completely relieved.

On section the kidney showed apparently normal exeretory units. The pelvis was definitely bifid in type, and there was no apparent dilatation of ureter, pelvis or calyees.

That the pain was due to the pull on the renal vessels with resultant compression and rotation of the kidney seems probable, at least in this case, as no dilatation, distention, or infection were demonstrable.

Encirclement of the entire upper renal pole by the main vessels has seldom been reported, if ever.

ACUTE MECHANICAL ILEAL OBSTRUCTION FOLLOWING APPENDECTOMY*

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INTESTINAL obstruction occurs not infrequently after appendectomy. When it ensues early it is usually the result of local or diffuse peritonitis and when it develops late it is most commonly due to bands and adhesions following peritonitis.

This report is concerned with a type of obstruction due to technical errors at the time of appendectomy. The unsuspecting surgeon may unconsciously contribute to this group if the anatomy is not carefully scrutinized when the mesentery of the appendix is ligated. If the ileum is inadvertently angulated during this step, an obstruction of varying degree may ensue. Subsequent to an otherwise routine operation, the convalescence is interrupted by symptoms of obstruction. The usual measures employed for the relief of postoperative pain, distention, vomiting and borborygmi fail. The denouement comes when the symptoms become so ominous that surgery again has to be resorted to for relief.

The following case reports illustrate obstruction secondary to angulation or kinking of the terminal ileum caused by technical errors in ligating the mesentery of the appendix.

CASE REPORTS

Case I. Mrs. E. G., age thirty-seven, was admitted to Cook County Hospital July 16, 1939, for a vaginal plastic operation and correction of a pelvic disorder. Operation was done July 20, 1939, and included an appendectomy which was incidental to the laparotomy. There was no evidence of disease of the appendix. Convalescence appeared to be un-

eventful for three days. During the next four days it was noted that the abdomen became progressively distended, and this was followed by abdominal pain and borborygmi. Intestinal suction relieved the symptoms temporarily, but when discontinued there was recurrence of the distention and pain. The use of enemas and mineral oil failed to alleviate the condition. There was no elevation in temperature or pulse rate, and the satisfactory general condition of the patient was maintained by the use of intravenous dextrose and salt solutions. On the seventh postoperative day it was thought advisable to re-open the abdomen. Exploration revealed the cause of obstruction. Proximal to the ileocecal junction, the terminal ileum was fixed to the cecum at the site of the appendectomy. (Fig. 1.) A sharp angulation of the ileum occluded its lumen. This angulation was released by severing the attachment of the ileomesenteric fold to the site of the inverted stump of the appendix. The obstruction was overcome immediately and intestinal contents entered the cecum.

More frequently mechanical intestinal obstruction at the ileocecal portion of the intestinal canal occurs as a late sequel to appendectomy. The following case report illustrates this type:

Case II. Mrs. A. W., age forty-one, entered Cook County Hospital July 14, 1940, with symptoms and findings of intestinal obstruction. A suprapubic midline scar represented an operation done one year before for removal of the uterus and tubes. An appendectomy was also done at that time. Intestinal decompression, enemas and intravenous fluids lessened the patient's distress, but mineral oil given by mouth failed to appear in the washings from the large bowel. On July 17, exploration of the

abdomen was done under spinal anesthesia. An obstruction of the ileum was found approximately 5 cm. from the ileocecal junction.

Case I

Case II

FIG. 1. The ileal pad of fat and its relationship to the cecum, appendix and meso-appendix. Case I and Case II showing fixation of ileal pad of fat to the cecum with kinking of the bowel. Arrows indicate site of release of obstructing peritoneal fold.

(Fig. 1.) What appeared to be the remaining portion of a short meso-appendix lying behind the ileum was fixed to the cecum at the site of the appendiceal stump. A sharp angulation of the ileum was present. Severance of the band released the ileum and the obstruction was promptly relieved as the intestinal contents freely entered the cecum.

DISCUSSION

The two cases cited above illustrate a hazard in appendectomy related to the meso-appendix, the ileocolic fold and the ileomesenteric fold. This complication may occur in those instances in which the meso-appendix is short. It may also take place when the ileomesenteric fold is inadver-tently clamped and ligated with the meso-appendix. Anatomically, the ileal pad of fat is related to the cecum, appendix and meso-appendix. (Fig. 1.) The ileomesenteric and ileo-appendiceal folds appear to a greater or lesser extent when the appendix lies medial or inferior to the cecum. The retrocecal appendix and its mesentery usually are not fixed to the terminal ileum by the ileomesenteric fold. Wakeley,[1] in an analysis of the position of the appendix in 10,000 instances, found the retrocecal appendix to be present in 65 per cent of the

cases. Thus, in almost two-thirds of the cases fixation of the meso-appendix to the cecum will not alter the position of the terminal ileum to any extent. In the remaining one-third of the cases, however, this possibility exists. In the two cases cited, infection (appendicitis) was not present at the time of the primary operation.

CONCLUSIONS

1. Intestinal obstruction following appendectomy is possible as a result of angulation and fixation of the terminal ileum. This complication may occur soon after appendectomy (Case 1) or at a considerable time later (Case 11).

2. Ligation of the meso-appendix should not include the ileo-appendiceal or ileo-mesenteric fold. It is better to ligate individual vessels than to ligate a broad meso-appendix en masse. The mass ligation may include the ileal attachment and disturb the normal relation between the ileum and cecum.

3. After ligation of the vessels, the attachment of the meso-appendix to the cecum would appear to offer an unnecessary hazard. It probably had better be left undisturbed in its natural position.

REFERENCE

1. WAKELEY, C. P. G. The position of the vermiform appendix as ascertained by analysis of 10,000 cases. M. Press, 134: 141, 1932.

PRIMARY MELANOTIC SARCOMA OF OVARY

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PRIMARY melanotic sarcoma of the ovary is exceedingly rare. According to statistics of various authors it varies between 1 and 6.5 per cent as compared with other tumors of the ovary. Although the literature contains many reports of metastatic melanotic tumors of the ovary, a careful review of these reports discloses only six cases that have been classed as primary and these will be enumerated later. The text books devote very little space to this condition, due to its rarity, but the best review of this subject is to be found in Ewing's "Neoplastic Diseases."

He defines melanoma as a "pigmented tumor arising from a specific mesoblastic cell, the chromatophore; probably also from tactile cells lying in the epidermis and probably also from nerve cells in the derma." Ewing recognizes as common sources of melanomas, pigmented moles and naevi, the choroid, iris and ciliary body, the pia arachnoid, adrenals and colon. Among disputed points of origin of melanoma he lists the gallbladder, liver and spleen, but does not mention the ovary.

The histogenesis is summarized by Ewing as follows:

1. Exclusively from mesoblastic chromatophores. (Ribbert.)

2. Exclusively from epithelial cells and epithelial chromatophores. (Post, Wieting, Hamdie, Favara.)

3. From nerve cells in the skin, and mesoblastic chromatophores in choroid and meninges.

4. From endothelial cells of blood and lymph vessels or of nerve trunks.

5. From chromatophores, tactile corpuscles and nerve cells forming the end apparatus of cutaneous sensory nerves. (Mason.)

It seems to be an accepted fact, that it would not be possible to have a primary melanotic sarcoma of the ovary unless there was originally within the ovary a dermoid cyst or a teratoma in which was incorporated some epithelial elements containing melanin.

The six reported cases that are considered as primary melanotic sarcoma of the ovary are as follows: (1) Soubetran and Rives;[2] (2) Andrews;[3] (3) Wintervitz;[4] (4) Amann;[5] (5) Westenhaiffer;[6] (6) Bab.[7]

The case herein reported, I consider as primary. Sections from the growth were submitted to three competent pathologists all of whom concurred in the diagnosis and were of the opinion that the growth originated in teratomas. As further evidence of the growth being primary, is the fact that there is no evidence of any tumor or growth from which there could have been metastases.

CASE REPORT

Mrs. H. F. B., a white, married woman, age thirty-three, was admitted to Greenwood Leflore Hospital on January 25, 1941, with diagnosis of pelvic inflammatory disease with probable ovarian cyst, twisted on the pedicle. Her chief complaints were pelvic pain with palpable mass for the past six months, flooding, severe cramping pain, left lower quadrant for past 18 hours, not relieved by morphine. The family history was unimportant.

Menses began at thirteen years, and was of the twenty-eight-day type. It was regular until three years ago when she began flooding. She had been married twelve years and gave no history of any pregnancy. This patient was examined by me one year before at which time she complained of flooding. Examination at that time revealed a mass in each side of the pelvis, about the size of a small lemon; both masses were tender, the mass on the right side being fixed. Surgery was advised but refused.

The present illness began eighteen hours before admission with severe cramping pain in the left lower quadrant. Pain was colicky

FIG. 1. Gross specimen of ovaries, tubes and uterus.

in type and was accompanied by painful urination. Patient had been nauseated and had vomited. She was seen by another doctor who gave morphine gr. ¼, but this failed to relieve the pain.

Physical examination revealed the patient to be 5 feet 6 inches tall, weighing 115 pounds. She was fairly well nourished and well developed. Facies was indicative of suffering. Temperature was 99.4°F., pulse 88, blood pressure 112/80, red blood count 4,080,000, hemoglobin 78 per cent, white blood count 10,240, small leucocytes 31 per cent, transitionals 5 per cent, polymorphonuclears 64 per cent. The chest was negative for any pathological condition and the heart regular, pulse 88, and no valvular heart disease.

The abdomen was rigid and exquisitely tender over the lower portion. In the lower left quadrant there was a mass palpable through the abdominal wall, irregular in outline and hard in consistency. The vagina was almost obliterated by the mass in the cul-de-sac, irregular in outline and firmly fixed.

A diagnosis was made of pelvic inflammatory disease with left ovarian cyst, twisted on its pedicle.

Under sodium amytal, ether, gas anesthesia, a midline incision was made. On the left side

was found a tumor of the left ovary, bluish in color, firm to touch, nodular, approximately 10 cm. in diameter; there were no adhesions and it was twisted on its pedicle. On the right side, there was a tumor similar in size and shape to the one on the left, but firmly bound down in the cul-de-sac by adhesions. The right tumor was easily freed from its adhesions, and a bilateral salpingo-oophorectomy, supra-

FIG. 2. Low power microphotograph of section of ovary.

vaginal hysterectomy was done. There were no other masses in the abdomen and no palpable glands or metastatic growths. There was no free blood or fluid in the peritoneal cavity.

The pathological report made by Dr. W. W. Robinson, follows: Section of tumor of the ovary is apparently well encapsulated, and approximately the size of a small orange. The

cut surface is meaty with much blackish pigment diffusely distributed throughout, as well as areas of hemorrhagic extravasation.

sists of a loose areolar connection tissue; there is injection of the blood supply as well as large areas of hemorrhagic extravasation.
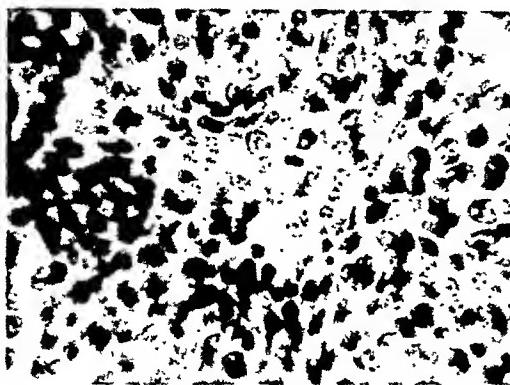
FIG. 3.   FIG. 4.
FIGS. 3 AND 4. High power microphotographs of section of ovary.
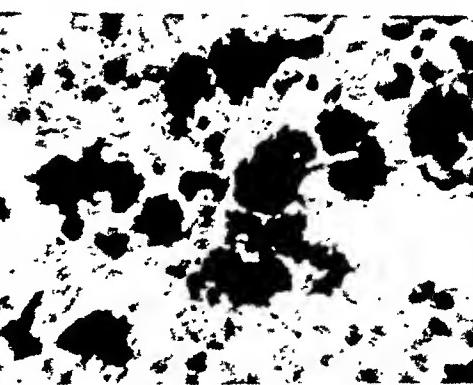
Pathological report: Parenchyma: Plexiform or ramifying masses of poorly differentiated, highly anaplastic mesoblastic or mesenchymal cells simulating fibroblasts, and showing two to six mitoses to the high power field are present. There is variation in the size, shape and staining characteristics of the cells. Many of the cells contain a melanin-like pigment. There is also much of this pigment distributed between the neoplastic cells, incorporated in macrophages, and laid down in large and massive deposits. Areas of liquefaction necrosis of the growth are present. Some infiltration with round cells is noted.

There is much thickening of the tunica albuginea which apparently encapsulated the neoplastic process. Directly beneath the tunic, and arranged in strata throughout the fibrous capsule there is much melanin pigment deposit. The supportive structure of the growth con-

Pathological diagnosis: Typical melanotic sarcoma of ovary.

This patient made an uneventful recovery and was dismissed from the hospital on the fourteenth day. At this time, May 1, *1941*, the patient is doing her housework, weighs more than she has in the past five years and so far has shown no evidence of any metastases.

REFERENCES

1. EWING. Neoplastic Diseases. 3d. ed. Philadelphia, 1928. W. B. Saunders & Co.
2. SOUBETRAN and RIVES. *Arch. gén. de chir.*, 5: 1098–1108, 1911.
3. ANDREWS. Cited by Wintervitz.
4. WINTERVITZ. 1909. *Bull, Johns Hopkins Hosp.*, p. 314, 1909.
5. AMANN. *Zentralbl. f. Gynäk.*, pp. 212–875, 1903.
6. WESTENHAIFFER. *Deutsche med. Wchnschr.*, May 1, 1902.
7. BAB. *Arch. f. Gynäk.*, 1906.

ADENOCARCINOMA OF THE RECTUM AND CHROMARGENTAFFINE TUMOR OF THE JEJUNUM*

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AND

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IN a review of the literature since 1930 we were unable to find any instance of adenocarcinoma of the rectum asso-almost daily laxatives, the past history was essentially negative. The family history was irrelevant.
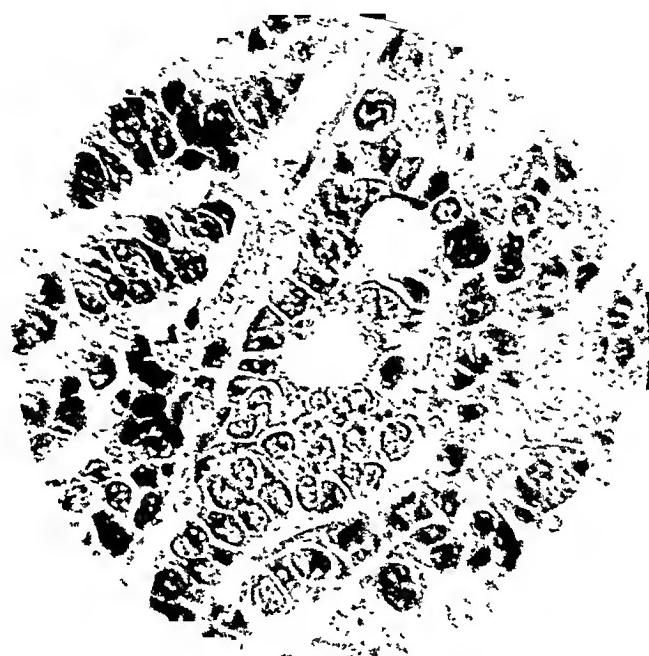
FIG. 1. Adenocarcinoma.

ciated with chromargentaffine tumor of the jejunum. We deem it worthwhile to report this case.

CASE REPORT

Mr. A. C., a forty-eight year old, married restaurant worker, entered the hospital on March 28, 1939, complaining of weakness and pain in the rectum. He was well until two months previous to admission when he experienced pain on defecation and his stools became covered with streaks of bright red blood. There was a weight loss of fifteen pounds and a moderate loss of strength since the onset. He had the usual childhood diseases. With the exception of chronic constipation which four years ago became more marked and required

On physical examination, the positive findings were limited to the rectum, where a tender 3 cm. ulcerated mass was felt in the midline on the posterior wall 4 cm. proximal to the anus. The blood pressure was 160/90. The urine was essentially normal. Hemoglobin was 80 per cent (Tallqvist), red blood cells 4.2 million, and white blood cells 10.0 thousand with 76 per cent polymorphonuclear leucocytes. The Wassermann test was negative. Proctoscopic examination confirmed the physical findings. A biopsy taken at that time revealed the presence of adenocarcinoma, type II plus. Laparotomy, on April 3, 1939, disclosed a fixed rectal mass firmly adherent to the pelvic floor. There were two 3 cm. metastatic nodules within the liver. A palliative colostomy was done and he was discharged on the thirty-eighth hospital day.

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On June 20, he was readmitted because of excruciating rectal pain and was given a subarachnoid injection of alcohol in the fourth lumbar space.

one-half months after the onset of the first symptoms.

Complete postmortem examination was done two hours after death with the following

FIG. 2. Jejunum with delicate villi and submucous clusters of chromargentaffine cells.
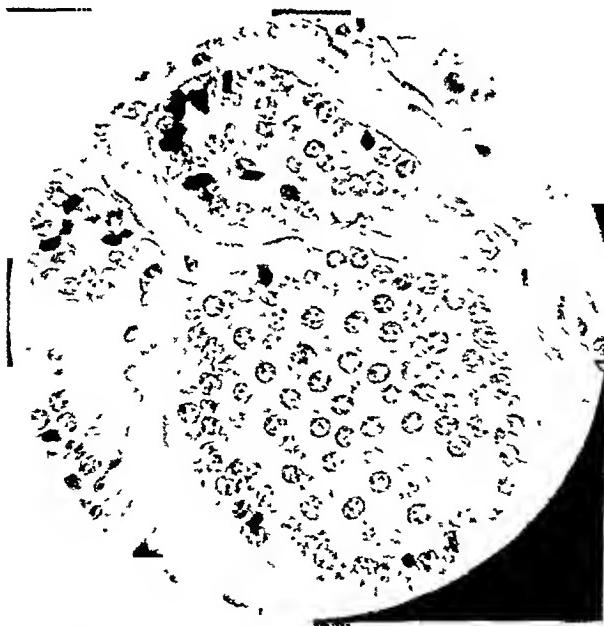
FIG. 3. Spheroidal cells with round nuclei, chromophobic cytoplasm and indistinct cellular membranes.

On August 6, the patient was admitted for a third time with severe perineal pain and another subarachnoid alcohol injection was given. He became progressively weaker and died with terminal pneumonia on August 14, five and

findings: terminal pneumonia, adenocarcinoma of the rectum, chromargentaffine tumor of the jejunum and metastatic adenocarcinoma of the liver and adrenals. The entire posterior cul-de-sac was filled with a 5 cm. firm mass

adherent to each lateral wall of the pelvis and completely encircling the rectum. The serosa in this region was deep red and interrupted by areas of granular pink tissue. On opening the rectum, the mucosa was pink and friable over a 3 cm. ulcerated area which had firm, pink, granular, elevated margins. The base of the lesion was of firm white granular tissue which extended through the muscularis and serosa.

Within the jejunum, 30 cm. distal to the ligament of Treitz, was a 1.5 cm. round nodule projecting into and partially obstructing the lumen. The overlying mucosa was smooth. On section, the tumor was roughly spheroidal, yellowish and fairly well encapsulated. The muscular coat was intact and the serosa was smooth and glistening.

Microscopical pathological report: Sections of the rectum show erosion of the rectal mucosa. (Fig. 1.) The inflamed, partially necrotic submucosa is invaded by diffuse masses or clusters of closely related polygonal epithelial cells which have a fine granular acidophilic cytoplasm and oval nuclei moderately rich in chromatin. The nucleoli are conspicuous and there are many mitotic figures. The neoplasm has a moderate tendency to glandular formation. The muscularis and the serosa are similarly involved. Malignant emboli of the blood vessels and lymphatics are conspicuous.

Sections of the jejunum show flattening of the villi with conspicuous atrophy of the mucosa. (Fig. 2.) Within the submucosa (Fig. 3) there are masses of closely related polygonal cells which have finely granular, moderately chromophobic cytoplasm, indistinct cellular outline with conspicuous perinuclear membrane; the nuclei are moderately dotted with scanty chromatin material and occasionally have chromatic nucleoli. The tumor is limited by a layer of low cuboidal cells. There are no demonstrable mitotic figures. The stroma is a fibrous structure with a moderate amount of a collagen material. The tumor is limited from the muscularis by a dense fibrous capsule.

CONCLUSIONS

1. Adenocarcinoma and chromargentaffine tumor, two separate, unrelated neoplasms, occurring in the same patient represent a rare finding.

2. Chromargentaffine tumors are most commonly located within the submucosa of the appendix, small bowel, stomach and colon. They are usually benign but they may give symptoms of obstruction.

3. In performing a laparotomy intra-abdominal exploration is important, even though the anticipated pathological condition is found.
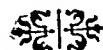
INFILTRATING SQUAMOUS CELL EPIDERMOID CARCINOMA INVOLVING THE OS CALCIS

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THIS case was selected for presentation because of the extremely rare occurrence of, first, the disease, namely, a

The wound, although much cleaner, never completely healed, and it was drained at intervals, followed by azochloramid dressings.

FIG. 1. A, photograph of gross specimen demonstrating extensive ulceration extending over the Tendo-Achillis. B, sagittal section of same specimen demonstrating destruction of the os calcis and obliteration of the calcaneoscaphoid joint with a fibrous ankylosis.

squamous cell epidermoid type of carcinoma in a chronic osteomyelitic cavity and, secondly, because of its location—the os calcis.

CASE REPORT

E. M., a white male, age thirty-four, a salesman, was admitted to the Hospital for Ruptured and Crippled on June 2, 1936, relating a history of a compound fracture to the left os calcis sustained in a crushing injury eighteen years previously in 1918. Subsequently, two years later a sequestrectomy was performed at another hospital, following which the wound closed and the patient was able to walk free from pain until March, 1936, when a sinus appeared, which later evolved into a deep ulcer at the back of the heel.

On June 10, 1936, an Orr treatment was performed, the os calcis was saucerized, old necrotic tissue excised, wound packed with vaseline gauze and plaster applied The plaster was removed three months later on September 15, 1936, by popular request.

In March, 1938, there appeared a crater like deformity posteriorly with much fibrosis of the overlying soft tissue.

In December, 1938, the wound appeared sufficiently clean to consider skin grafting, but the development of a bony exostosis from the os calcis, extending through the wound, prevented this procedure. Exostectomy was done December, 1938, at which time no sequestrum was found, and there was not much evidence of infection. The bone appeared sclerotic and eburnated.

The patient continued ambulatory, requiring only infrequent dressings, until March, 1939, when while riding in his car the foot began to bleed freely. He was re-admitted to the hospital and a pressure dressing was applied. The wound appeared not unlike a rodent ulcer, with a large open malodorous mass of greyish granulations fungating in appearance. Biopsy at this time revealed chronic suppurative inflammatory tissue with epithelium growing along a sinus tract. It was considered precancerous and had the appearance of a

FIG. 2. Roentgenograms, taken September 14, 1937, showing an extensive old deformity involving the posterior half of the calcaneus with spurs on the medial side and some small sequestra. No large necrotic bodies are seen.

FIG. 3. Roentgenogram, taken April 24, 1939, after removal of most of the calcaneal tuberosity. The raw surface seems rough and moth eaten in appearance and is blurred by soft tissue swelling. A number of densities suggestive of dead bone may be seen.

fungus infection. Repeated cultures on special media for fungus were negative. The patient continued to take a retrograde course with a

with inflammatory histiocytes. *Diagnosis:* Infiltrating squamous cell epidermoid carcinoma.

The prognosis of this disease is very
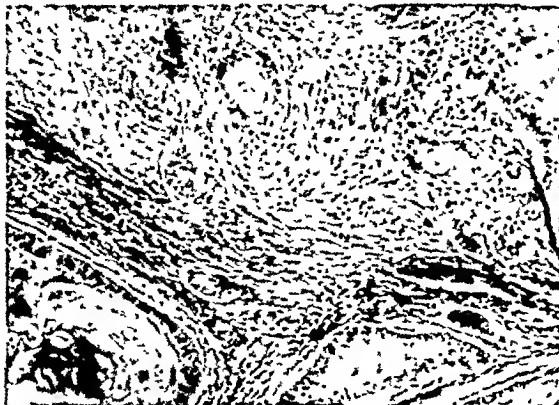
FIG. 4. Photomicrograph of a section taken from a block of the soft pulpaceous material which replaced most of the os calcis, showing a loose fibrous stroma richly infiltrated with histiocytes. X 120.
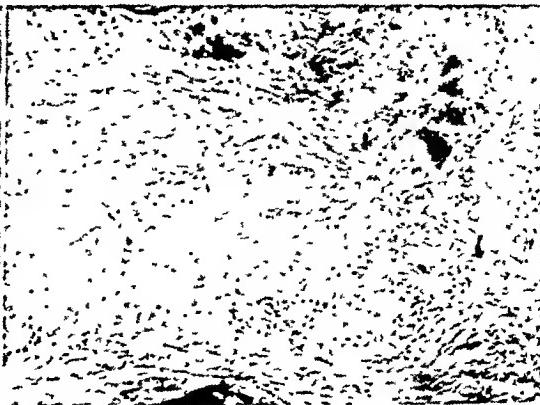
FIG. 5. Photomicrograph demonstrating bizarre overgrowth of stratified squamous epithelium with occasional mitotic figures. X 120.

temperature varying between 101 and 102°F. so that amputation at the midshaft of the tibia was performed on May 9, 1939.

The pathological specimen revealed multiple abscesses with destruction of the posterior two-thirds of the os calcis, being replaced by a pulpaceous yellow mass of gritty, friable consistency.

Histological section showed a bizarre overgrowth of stratified squamous epithelium with occasional mitotic figures. This section was taken from a block of the soft pulpaceous material which replaced most of the os calcis. It showed an overgrowth of stratified squamous epithelium, made up of atypical cells which are large, irregular, with prominent nuclei with occasional mitotic figures. There was a great deal of necrosis of the tumor and there was a loose fibrous stroma which was richly infiltrated

favorable though histologically malignant clinically, it runs a relatively benign course.

As a result of the treatment in this case and because of the relatively short duration of the condition, amputation most likely will preclude recurrence. However, the possibility of its appearance in any case of long standing osteomyelitis should be borne in mind.

REFERENCES

BENEDICT, EDWARD B. Carcinoma in osteomyelitis. *Surg., Gynec. & Obst.*, 53: 1–11, 1931.

BLANCO, PIO. Squamous-cell epithelioma originating in chronic osteomyelitic cavities, reporting two cases. *Am. J. Cancer*, 19: 373–378, 1933.

BRUNSCHWIG, ALEXANDER. Epithelization of bone cavities and calcification of fibrous marrow in chronic pyogenic osteomyelitis. *Surg., Gynec. & Obst.*, 52: 759, 1931.

HARRISON, J. H. Epidermoid carcinoma in osteomyelitis; case report. *Am. J. Cancer*, 32: 527, 1938.

INTESTINAL PERFORATION FROM INGESTED FISHBONE

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MOST of the edible fishes are quite bony. Although in most varieties segmentation of body structure greatly facilitates their recognition and removal after cooking, many bones are swallowed. Careless eating, particularly in children, insensitive denture plates, poor vision, mental infirmity and drug addiction often are contributing factors.

The long bones of fishes differ from those of birds and of animals in that they vary little in size from base to tip. They are of fine texture with both ends sharp and with length out of proportion to circumference. The small mineral content permits a flexibility not possessed by other bones. Thread-like in outline, offering no contrast in color and giving but little sense of resistance in mastication, even when due care is taken in eating, they are unwittingly swallowed.

Ordinary cooking has but little effect upon the integrity or the penetrating qualities of fishbone for in frying, roasting or boiling a temperature of 212°F. is maintained only for a short time. In commercial canning,[3] however, fish are subjected to a much higher temperature (260°F.) for an hour or more. This, through an obscure chemical change, causes partial disintegration of bone so that it becomes soft and friable.

The fate of ingested fishbone on entering the stomach depends upon the duration of its stay and upon the degree of acidity encountered. In cases of low acidity it is but little effected by the process of digestion; but if the gastric secretion is highly acid, the organic matrix is digested and the inorganic mineral content dissolved. Knud Faber[2] found bones in the stools of twelve patients having achlorhydria after they had eaten fish and no bones in the stools of those having normal gastric digestion. In most people small bones are made harmless by digestion before reaching the intestine. Handles of pearl and of bone have been found to have been digested from pocket knives retained in the stomach of a professional swallower or human ostrich.

The likelihood of perforation by fishbone that reaches the intestine undigested is lessened by its ability, being flexible, to conform to the changing intestinal peristaltic pattern, although Armitage[11] found at a single operation three widely separated perforations of the small intestine, each marked by a partly protruding fishbone. It is remarkable that ingested needles, pins, spicules of glass and other sharp-pointed foreign bodies becoming incorporated in fecal masses, as a rule, pass without causing symptoms. Of 800 cases of ingested foreign bodies of all kinds seen at the Boston City Hospital only 1 per cent caused perforation.[2]

We can only guess at the percentage of ingested fishbones that perforate for there is no way of knowing how many bones are swallowed and a perforation, as in one of our cases, may heal spontaneously without being suspected. Except in infants, fishbone is the most frequently ingested foreign body. If the very few cases of intestinal perforation reported in the literature are compared to the tons of fish eaten daily by civilized people, the incidence of perforation must indeed be small.

The ultimate disposition of a fishbone after perforation varies. In most cases it passes from the lumen of the intestine through the perforation into the peritoneal cavity. It is possible, however, even after a sharp end has perforated the intestine several times, for the bone to remain in the lumen and be discharged by the anus. Small perforations of the intestine cause no eversion of the mucosa and heal spontane-

ously without reaction as do those made by individual birdshot in shotgun wounds of the abdomen.[15] A bone extruded from the intestine may migrate. An ingested fishbone has been found in an abscess of the liver.[14] A fishbone was found by us lying free on the anterior surface of the great omentum. Wood[10] reports a case of spontaneous recovery after the removal of a fishbone which, after perforation, had passed through the anterior abdominal wall and pierced the skin, and David[16] reports a case of long continued indigestion, pain and bladder irritation which was relieved by the passage of an ingested fishbone through the urinary meatus.

When localization of infection occurs after perforation, the bone is apt to be contained in the resulting abscess or to become incorporated in the chronic inflammatory mass which so often forms. Psoas pyogenic abscess of unexplained origin may be from this cause. In distinction from cases of acute perforation, from complicating pathological conditions and persistent symptoms, these are cases of so-called chronic perforation, and most perforations from foreign bodies are in this sense chronic.

Fish is such a common article of food that the history of having eaten it before the onset of symptoms is not of much significance in diagnosis. Diagnosis can be made only at operation or at autopsy. Most of the patients with acute perforation are operated upon for appendicitis. An ingested fishbone is too small to be shown by x-ray.

Symptoms vary with the site and the size of perforation for these are factors which largely determine the ability of the patient to overcome or to localize the resulting peritoneal infection. It is possible for fatal peritonitis to develop after perforation particularly in patients with low resistance. Symptoms also vary with the portion or segment of intestine involved. In the duodenum or stomach, if there is gross soiling, the abdominal rigidity of acutely perforating peptic ulcer may occur; in the small intestine there is apt to be

pain followed by tympanites as in perforating diverticulitis; in the colon the symptoms are those of perforating appendicitis or diverticulitis. Fortunately, as a rule, the perforation is small and at a site favorable for localization. In these cases spontaneous recovery may take place, an abscess may form or the inflammation may become chronic without abscess. Stone[13] reports a case of resection of the stomach for cancer in which the condition proved to be an inflammatory mass containing a fishbone which had passed through the stomach wall. Inflammatory masses about the colon from this cause may readily be confused with chronic diverticulitis or malignancy.

Hemorrhage either into the intestinal lumen or elsewhere is rare although, according to Bearse,[12] a case has been reported of fatal gastric hemorrhage caused by a fishbone perforating the posterior stomach wall and a fishbone has been found in the superior mesenteric vein. In our case, in which a fishbone was found with one end in the internal iliac vein and the other in the lumen of an adherent loop of terminal ileum, there was no evidence of bleeding found at autopsy.

Henderson and Gaston,[2] in a comprehensive study of gastrointestinal perforation from ingested foreign bodies, report nine cases with two deaths in the Boston City Hospital, none of which was from fishbone. In sixty-two cases of perforation collected by them from the literature eleven of the patients died, (25 per cent); of the five cases in which the perforation was from ingested fishbone with one death (20 per cent), all were complicated by abscess. The locations were the stomach, the pylorus, the hepatic duct, and the splenic and sigmoid flexures of the colon. In neither series was there an acute perforation by fishbone. In our series of five cases all have been acute perforations with one death on the fifth day after admission from septicemia following perforation of the ileum and penetration of the bone into the right iliac vein. It was the only patient

not operated upon. In two cases Meckel's diverticulum was the site of perforation. In one the appendix was the probable site although the bone was found free in the peritoneal cavity. In one the site was undetermined for no evidence of inflammation or trauma could be found anywhere.

The treatment of intestinal perforation from any cause is entirely surgical. Even at laparotomy, however, the offending fishbone may not be identified and the true nature of the lesion be unsuspected. In no case, noted by us, of abscess or chronic inflammatory mass containing a fishbone has the perforation of the intestine been found, in no case has it been closed and in no case has fecal fistula resulted. It is of interest to note that Siddons,[1] in a study of 126 patients with foreign bodies admitted into three large London hospitals, advises that ordinary diet, without laxatives, be given after ingestion. Bulky foods, if the bodies are large, encourage obstruction and do no good even in the case of sharp objects.

CASE REPORTS

Case I. A negro woman, J. F., forty-six years old, without history of previous trouble, entered the Good Samaritan Hospital for relief of pain about the navel of four days' duration. The temperature and blood count were normal. At laparotomy a fishbone one inch long was found lying free on the outer surface of the great omentum. No evidence of trauma or inflammation was found. Spontaneous recovery had taken place.

Case II. (Case of Dr. LeGrand Guerry.) Mrs. C., white, age twenty-three, on admission to the hospital had a temperature of 101°F., blood cells 8,900, polymorphonuclears 75 per cent. She had complained of epigastric pain for two days with no previous attacks. She was operated upon for acute appendicitis. Subacute catarrhal appendicitis was found. A fishbone one inch long was lying free in the peritoneal cavity. The site of the perforation could not be determined. Recovery followed appendectomy.

Case III. H. F., a white man, age fifty, entered Providence Hospital with the diagnosis of acute appendicitis. Two days previously he had sudden pain in the lower portion of the abdomen without nausea. There was tenderness and rigidity over McBurney's point. He had a chill with temperature of 99.5°F. which rose the day after operation to 103°F., white blood cells 9,650, polymorphonuclears 62 per cent. At operation there was a fishbone protruding from the end of Meckel's diverticulum. Both the appendix and the diverticulum were removed and the patient recovered.

Case IV. G. W. W., a white male, aged forty, entered Columbia Hospital with the diagnosis of acute appendicitis. The onset was with pain in the abdomen six or eight hours previously. The white blood cells were 10,200 with 81 per cent polymorphonuclears. At operation acute diverticulitis was found with a perforating fishbone three-fourths inch long protruding from the diverticulum. The appendix and the diverticulum were removed and complete recovery followed.

Case V. A white man, aged forty-eight, entered the Columbia Hospital November 19, 1933. He had once been a patient in the South Carolina State Hospital for the Insane. He had complained of pain for several days in the right lower quadrant which radiated down the thigh. On physical examination there was rigidity and tenderness over the right lower portion of the abdomen but there was no distention. There were 10,000 white blood cells, 88 per cent polymorphonuclears, with no malaria. The urine was normal. The temperature was 102°F. on admission and reached 106°F. several times, each preceded by a chill, before he died unoperated upon on the fifth day after admission. There was mild jaundice.

Autopsy by Dr. Plowden revealed miliary abscesses throughout both lungs. A sharply angulated loop of ileum was found adherent to the right iliac vein with an opening into the intestine communicating with an opening into the vein and extending through both openings was a fishbone of small caliber, one and one-fourth inches long with both ends sharp and pointed. The cause of death was blood stream infection with multiple pulmonary abscesses resulting from perforation of the intestine and right internal iliac vein by a fishbone.

SUMMARY

We report five cases of acute perforation of the intestine by ingested fishbone in

each of which the bone has been found within the abdomen.

The site of perforation in two cases was a Meckel's diverticulum, in one case probably the appendix. The incidence of perforation in these blind segments is explained by their inability to rid themselves of the offending bone. Once it has entered, peristalsis forces it onward.

Cases I and II prove that when a perforating fishbone of small caliber is completely extruded from the intestine or falls back into the lumen so that the bone no longer pierces the wall of the intestine, the lesion made by it tends to close spontaneously without leakage, without peritonitis and without trauma of sufficient degree to mark the site.

An extruded fishbone tends to migrate and may cause an abscess far removed from the site of perforation.

Case V is unusual in that penetration of the internal iliac vein by the perforating bone was followed by fatal blood stream infection.

REFERENCES

1. SIDDONS, A. M. H. The fate of swallowed foreign bodies. *J. A. M. A.*, 113: 17, 1577, 1939.
2. HENDERSON and GASTON. Ingested foreign body in the gastrointestinal tract. *Arch. Surg.*, 36: 66, 1938.
3. FEASTER, J. F. Research Dept. Am. Can Co. Personal communication.
4. PIQUARD and GRENET. Perforation of an ileal diverticulum by a fishbone. *Bull. et mém. Soc. anat. de Paris*, 2: 390, 1900.
5. BRUNING, F. Perforation of the large intestine by a fishbone. *Zentralbl. f. Chir.*, 53: 1563–1564, 1926.
6. WATSON, F. S. Perforation of the stomach and intestine by foreign bodies that have been swallowed. *Boston M. & S. J.*, 172: 622–625, 1915.
7. THAWKYARD and ARMITAGE. Peritonitis due to perforation of the bowel by foreign bodies. *Brit. M. J.*, 3665: 577–578, 1931.
8. HAGLER and STEWART. Acute perforation of Meckel's diverticulum by fishbone. *J. A. M. A.*, 74: 1377, 1920.
9. FRY, W. Fishbone perforating the coecum. *Virginia M. Monthly*, 66: 173, 1939.
10. WOOD, W. A. Fishbone extruding through the abdomen. *Intercolon. M. J. Australasia*, 9: 24, 1904.
11. ARMITAGE, G. Three perforations of the ileum by fishbone. *Brit. M. J.*, 1: 307, 1938.
12. BEARSE, C. Fishbones as a cause of intestinal perforation. *New England J. Med.*, 201: 885, 1929.
13. STONE and OWINGS. Perforation of stomach by a fishbone. *Am. J. Surg.*, 25: 180, 1934.
14. WILHEIM, E. Hepatic Abscess Caused by Fishbone, *Zerb für Chirurgie*, July, 1925. Gen. Surg. 1926, 490. Year Book Publishers.
15. BUNCH, GEO. H. Treatment of shotgun wounds of abdomen. *Tr. South. S. A.*, 41: 38–41, 1928.
16. DAVID, I. An errant fishbone. *Brit. M. J.*, 1: 166, 1918.

STRUMA OVARII*

CASE REPORT

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THE unexpected histological report that a large ovarian tumor consists almost entirely of thyroid tissue is always startling. Similar findings have been sporadically reported.[1,2,3] Emge,[4] in 1940, reported on the functional and growth characteristics of such tumors and brought the literature up to date, adding two cases to the some 150 cases previously reported. The relative rarity of the tumor warrants the report of this additional case.

The essential features presented in this instance are that of a large, unilateral, asymptomatic, ovarian mass which made itself known only by reason of regional pressure. Histologically, the tumor mass, which measured 14 by 8 cm. consisted entirely of thyroid tissue, the ovary itself being compressed and distorted. The slight ascites noted at operation recalls similar findings in the other ovarian tumors (Meig's Syndrome).[5] There were no constitutional changes noted in the patient preoperatively so metabolic studies had not been done. The basal metabolic rate determination four weeks postoperatively was minus 4.

CASE REPORT

B. I., a fifty-seven year old married housewife, entered the hospital on March 30, 1941, complaining of vague abdominal pains of many years' duration. The family history was unessential. Past history revealed that she had undergone a uterine suspension and appendectomy in 1913; in 1930 a cholecystectomy had been performed, followed by a second laparotomy for adhesions.

The patient was married twice, had two living children and had had no abortions. She had menstruated regularly since the menarche, the menses occurring uneventfully save for mild pains before the flow. In 1932, at the age

Fig. 1. Cross section of the tumor photographed after fixation and removal of sections for microscopic study.

of forty-eight, a normal menopause occurred with no subsequent bleeding. She had been followed in the out-patient clinic since 1928 and several pelvic examinations were negative except for a third degree rectocele, so it would appear that the tumor developed to its present size late in life.

The physical examination revealed an obese, middle-aged woman in no distress. Temperature was 37, pulse 80, respirations 22, and blood pressure 170/90. Her skin was white and clear. The pupils were equal and responded to light and accommodation. The heart was normal in size. Rhythm was regular and sounds were clear but distant. There was a loud blowing, harsh, aortic systolic murmur. Lungs were clear save for a few crackles at the bases. The abdomen was obese and protuberant. There were two surgical scars, one in the right upper quadrant and one in the midline below the umbilicus. Pelvic examination revealed a left adnexal mass slightly tender and fixed, about 8 by 14 cm. There was a first degree cystocele and rectocele. External

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hemorrhoids were noted. The remainder of the physical examination was essentially negative.

The preoperative diagnosis was left adnexal

Fig. 2. Photomicrograph showing types of thyroid acini filled with colloid.

mass, probably cystic ovary, and third degree rectocele. The operation by one of us (A. L. B.) was performed March 31, 1941 under cyclopropane anesthesia. The abdomen was entered through a midline incision. A left ovarian mass was readily enucleated. Ascites to the extent of 400 cc. of clear yellow fluid was present. The remainder of the pelvic viscera appeared normal. Perineorrhaphy was performed.

The patient made an uneventful recovery, the wound healing per primum, and she was dismissed on the twelfth postoperative day. Subsequent metabolic studies were normal. (Basal metabolic rate one month postoperatively −4.)

The pathological report was as follows: Gross: Specimen consists of a firm, nodular, pearly grey, completely encapsulated mass to which a segment of tube is attached, the main mass measuring 14 by 8 by 6.5 cm. Microscopic: Sections show the ovarian parenchyma

in places to be compressed and distorted. Very little ovarian tissue is present and no follicles are seen. Sharply demarcated from the

Fig. 3. Another portion showing thyroid without colloid.

ovarian tissue are areas of thyroid tissue. The latter is composed of acini of various sizes and shapes; some are small and compact with tall columnar epithelium. Varying amounts of colloid are contained in the acini. There is a variable amount of interstitial fibrous tissue. Large areas of replacement by loose connective tissue are seen in the thyroid tissue. In the ovarian stroma adjacent to the thyroid tissues are seen some clusters of lutein cells. There is no evidence of malignancy. Sections through the tube show slightly thickened villi, but the walls are normal.

REFERENCES

1. Nicholson, G. W. Guy's Hosp. Rep., 87: 301, 1937.
2. Morson, G. L. Surg., Gynec. & Obst., 40: 150, 1920.
3. Wynne, H. M. N. et al. Am. J. Obst. & Gynec., 39: 263, 1940.
4. Emge, L. A. Am. J. Obst. & Gynec., 40: 738-750, 1940.
5. Harris, F. I. and Meyer, M. Surgery, 9: 877-903, 1941.

LARGE OVARIAN CYST IN NEWBORN CHILD*

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THE ovary is the most frequent site of cyst formation in the body. Pathologically, ovarian cysts appear to be the result of inflammation, retention or degeneration, the changes taking place after a certain developmental stage and indicating some degree of maturity. More rarely these cysts grow as true tumors or cystadenomas and may occur at all ages. A search of the recent literature reveals that the presence of such cystic tumors in the newborn is extremely rare. Issacs and Schwartz[1] reported a case of twisted ovarian cyst in a girl three years of age. Likewise, Delthil[2] reported torsion of an ovarian cyst in a child twenty-six months old. The case herein presented concerns an infant who at birth showed evidences of an abdominal tumor that proved to be an ovarian cyst at operation thirty-six days later.

CASE REPORT

J. K., a female, was born at 3:59 a.m. on January 23, 1941 at the Shamokin Hospital following a normal delivery. While the cord was being severed, marked abdominal distention was noted. An x-ray examination on January 24, 1941 was reported as follows: "There is an apparent neoplasm of the abdomen displacing the intestines to the left side of the abdomen." No masses were felt. The abdomen was soft. The percussion note was dull on the right side of the abdomen while the left side was tympanitic. Rectal examination disclosed nothing significant. The child did fairly well, except for occasional vomiting after meals and constipation. Castor oil and colonic irrigations were used and, although not too effectual, did afford some relief. On February 2, 1941, another x-ray showed "an apparent increase in the size of the suspected mass." The child was allowed to go home and the mother instructed to return with her in two weeks.

Examination on February 24, 1941 revealed a well nourished child of good color. There was no change in the appearance of the genital organs. There was marked distention and asymmetry of the abdomen, the right side being much more enlarged than the left side. No masses were palpable. The abdomen was soft but had a peculiar doughy consistency on the right side. There was dullness over the entire abdomen. Rectal examination was negative. The mother stated the child had maintained her weight. The appetite was good but shortly after each feeding she vomited. The bowels were constipated. She slept a great deal, except for spells in which she cried vehemently as though she "were having colic." X-ray examination at this time revealed "A definite enlargement of the abdomen since the previous examination; apparently caused by a tumor in the right lower quadrant." The child was admitted for further study. Three days later subcutaneous urography disclosed "excellent secretion from both kidneys with no evidence of abnormality or obstruction on either side." A cyst, either mesenteric or ovarian in origin, was suspected.

On March 1, 1941, exploratory laparotomy was performed. Through a right rectus incision, a large soft mass was encountered, bluish in color, extremely thin-walled and occupying the entire abdominal cavity. Exploratory needling revealed the presence of straw-colored fluid. The size of the cyst made removal *in toto* impossible so that the contents were emptied with a trochar. The cyst was found attached to a long pedicle that arose from the left ovary. Oophorectomy was accordingly performed. Another small cyst, about the size of an orange seed, was removed from the right ovary. The remaining abdominal organs were normal. The abdomen was closed in layers without drainage. The child had an uneventful recovery and was discharged from the hospital in fourteen days.

The pathological report was as follows: "The specimen consisted of a large ovoid cyst measuring 15 cm. × 13 cm. It had paper thin walls and was partly filled with straw colored fluid. The inner surface of the cyst was smooth, except for two small pea-shaped projections. Microscopically, the cyst was lined with flattened cuboidal cells. There were some glands in the coat of the thickened portion." Diagnosis: Cystadenoma of ovary.

COMMENT

The case presents many points of interest. Ovarian cysts in infants and young children, unless of sufficient size to produce abdominal enlargement, usually attract attention by becoming twisted upon themselves and giving rise to an acute abdominal condition. In this case, although the cyst was from the left ovary, a long pedicle accounted for the enlargement of the right side of the abdomen, demonstrating the ease of torsion. The presence of a small cyst on the right ovary indicated the possibility of bilateral or multiple cysts at an early age. The abdominal distention at birth and the x-ray findings strongly suggest the cyst had reached considerable size in utero. No explanation is available for the occurrence of such tumors in the newborn except unrestrained physiologic growth.

REFERENCES

1. Bowen, Harry L. and Schwartz, Albert M. Twisted ovarian cyst in a three year old child. Am. J. Surg., 41: 268, 1938.

2. Dreyfus, P. Torsion of a dermoid cyst of the ovary simulating appendicitis in a child twenty-six months old. Bull. soc. de pediat. de Paris, 35: 64, 1937.

New Instruments

A NEW GASTROINTESTINAL SUCTION-IRRIGATION DEVICE*

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THE brilliant work of Wangensteen has established beyond any doubt the value of continuous suction-siphonage in the treatment of certain types of gastrointestinal distention. Having observed for some time the operation of the standard Wangensteen apparatus, it was seen to have a few minor drawbacks. In the first place, the set-up is somewhat unwieldy and occupies too much space at the bedside. Secondly, the duration of its action is relatively short and, consequently, it requires frequent and laborious attention to keep it in proper operation.

In the third place, it provides no adequate means of irrigation or flushing of the tube and bowel. This is a serious disadvantage, for the material in the bowel often needs greater dilution or emulsification in order to prevent clogging of the holes of the Miller-Abbott or Levine tubes.

Finally, the actual appearance of the Wangensteen apparatus and the constant manipulation and bottle changing required must be a source of considerable apprehension on the patient's part. It was with these various disadvantages in mind that a more compact, longer acting and more efficient type of apparatus was conceived which would combine both suction and irrigation.

As may be seen in Figure 1, this device consists of three glass bottles. Two of them, A and B, are used to store partial vacuum.

They are joined to each other by means of a one-quarter inch copper tubing and two-holed rubber stoppers, in the manner
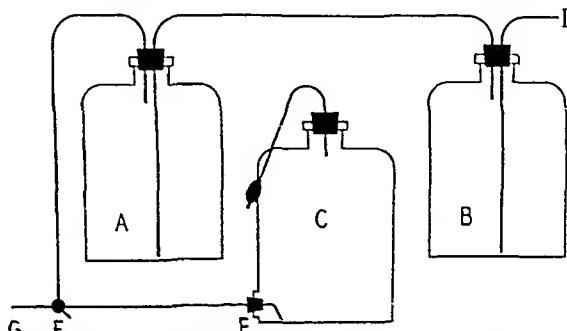
FIG. 1. Blaisdell gastrointestinal suction-irrigation device.

illustrated. They are evacuated simply by connecting them at I to a faucet water-suction pump or aspirator such as may be found in almost every hospital, either in its laboratories or operating rooms.

The third bottle, C, has an outlet at its bottom in addition to the one at the top. To the latter is attached a rubber bulb pump of the type used with a sphygmomanometer. (A small bicycle pump might do as well.) The rubber stopper in the mouth of the bottle should be wired and bolted on in such a way that it can easily be removed at will by unscrewing a wing nut, but will not blow off when the pressure within the bottle is increased by pumping. The rubber stopper in the bottom outlet should be wired on permanently. This third bottle, C, is designed to serve

as an irrigating bottle and it will be readily understood that pumping air into the bottle from above will tend to force fluid at a

was suspected of having swallowed iodine, a solution of starch water was placed in the irrigating bottle and the stomach

FIG. 2. Illustration showing the use of the suction-irrigation apparatus.

regulated pressure out of the bottom outlet.

At F is an easily operated three-way valve or stop-cock which connects the vacuum bottles to the irrigating bottle, and all three in turn to the gastrointestinal tube. This valve is of the type to be found in any auto supply store and is designed to connect an extra gas tank to a feed line. The operation of this valve is quite simple for, by turning its handle clock-wise, the vacuum bottles are permitted to suck on the gastrointestinal tube. When the handle is turned in the opposite direction, the irrigation bottle may be operated. If the handle is turned midway between the extremes of these two positions, the valve will be closed entirely.

The apparatus seems to have most satisfactorily demonstrated that it has eliminated most, if not all, of the serious disadvantages peculiar to the standard Wangensteen apparatus. Indeed, the effect of the irrigating device is comparable to that of a lavaging agent and has been found most valuable in washing out the stomach in postoperative vomiting or in poison cases. In one case in which a patient

thoroughly flushed even as the patient was vomiting.

Its most gratifying performances have been seen in connection with seven patients who were treated recently for intestinal obstruction by means of Miller-Abbott intubation. In these cases, all of its advantages over the old type of suction apparatus were most evident. Its ease of operation, efficiency and appearance are obvious at once. Moreover, the duration of its vacuum is about three to twelve hours, depending on how much material is present in the bowel and how actively the gastrointestinal tube and the bowel are irrigated. When the vacuum is exhausted, it is only necessary to connect the vacuum bottles to the nearest suction pump for about twenty minutes. The tubing is so arranged that the fluid previously sucked up in the bottles is drawn out along with the air so that it is not necessary to take apart the apparatus in any way in the course of re-evacuation.

Evacuation of the vacuum bottles is more rapid, especially if the amount of fluid in them is considerable, if the handle of the valve is turned to the suction position until all the fluid has been withdrawn.

Then the valve should be closed and the exhausting process continued for twenty minutes.

2 4-liter vacuum bottles...........	$2.20
1 4-liter irrigating bottle.........	1.50
1 three-way valve and bushings...	2.20
1 sphygmomanometer bulb.......	2.25
3 ft. ¼ inch copper tubing.......	.30
3 ft. rubber tubing..............	.30
1 Hoffman clamp................	.17
rubber stoppers...............	.30
	$9.22

The suction exerted by the freshly evacuated bottles can be easily regulated as desired, by manipulating the three-way stop-cock so that no damage can occur to the mucosal surface of the bowel by too great a pull. (Fig. 2.)

The approximate cost of the materials used in making this apparatus are listed in the accompanying table.

Many of the above items need not be purchased new, but will be found handy about a hospital laboratory. Most of the materials will never need replacement so that there is a minimum of upkeep. It has been found that rimming the rubber corks with collodion or rubber cement will produce an excellent seal which need not be broken until the apparatus requires cleansing.

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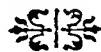
DUPLICATIONS (of the alimentary tract) are spherical or elongated hollow structures which possess a coat of smooth muscle, which are lined by a mucous membrane, and which are intimately attached to some portion of the alimentary tube. They may appear at any level from the base of the tongue to the anus. They are more commonly found in relation to the small intestine than to any other part of the gastro-intestinal tract.

From—"Abdominal Surgery of Infancy and Childhood"—by William E. Ladd and Robert E. Gross (W. B. Saunders Company).

GREATER DESCRIPTIVE ACCURACY AT THE OPERATING TABLE*

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IT is obviously desirable to have measurements of the size of various pathological lesions encountered in the course

is almost invariably among the operating instruments, namely, the scalpel, the handle of which may be marked with the
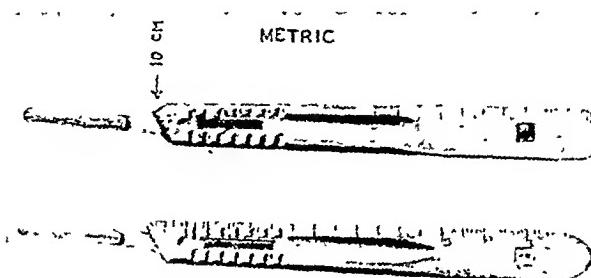
FIG. 1. Scalpel handles marked with metric scale, the lower one throughout its entire length, the upper one for a distance of 5 cm. It will be noted that the total length of the handle to the point of insertion of the blade is 10 cm.

of operations. In such circumstances, the size is ordinarily estimated by eye, with an accuracy dependent upon the individual. Size is frequently expressed in terms of familiar objects, a method which has evident disadvantages due to variations in the size of the objects used as a standard. Complicating the operating kit by inclusion of an extra article for the sole purpose of measuring (such as a conventional ruler), which may not be needed, also has drawbacks. One object which lends itself to use as a measure, however,

metric scale, either throughout its length or the fine markings limited to a portion of the handle with a notation as to the total length up to the point at which the blade is inserted. Both methods of marking are illustrated. (Fig. 1.)

The cost of engraving marks on the handles of scalpels is relatively high; but if there were a widespread demand it is likely that they could be stamped on, easily and inexpensively, during the process of manufacture.

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A NEW BREECH FORCEPS

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THIS instrument, which I have been using on all cases of breech delivery for several years, I believe is an cervix is fully dilated invites a fractured femur or humerus. With the hand well lubricated with heavy green soap (thin
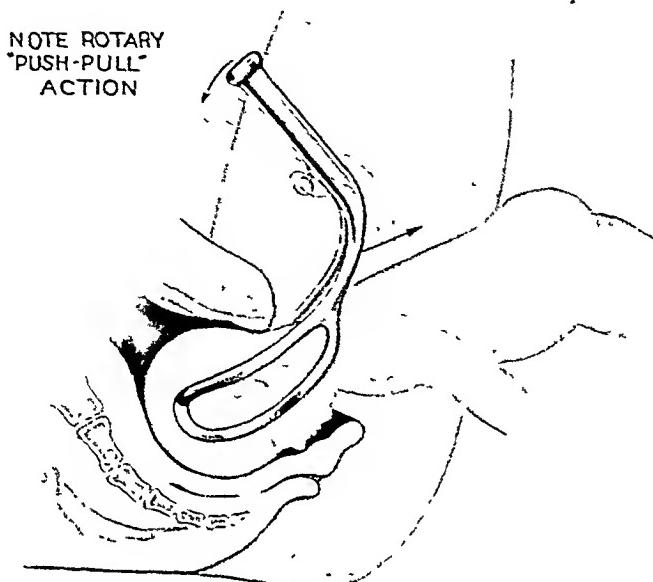
FIG. 1. The general shape of the blades is similar to the Elliot pattern. The handles fit together with a swivel action. The two blades are detached for application as in the regular forceps. When applied to the baby's head, the blades are locked together by a thumb set. When locked together they stay set in proper position. Note curve in handles to fit over the pubis. The spread of blades at the tip is from three inches down.

entirely new type of forceps. After repeated remodeling it now seems satisfactory. The cut is self explanatory. The idea is to apply the forceps *over* the child's body instead of *under*. Also the curve of the instrument allows the sweep up and over the pubis without hindrance from the baby's body.

The patient should be in the lithotomy position down to the edge of the table. I prefer that both feet be delivered first and together. This can be done at any stage of delivery, even though the buttocks show at the vulva, provided the patient is under full anesthesia. To attempt this without full anesthesia and before the

soap is a mistake) the buttocks can be pushed back up into the well relaxed uterus and the feet easily brought down. After both arms are delivered allow the baby's body, face down, to drop down over the edge of the table. At this stage, with the old type forceps, the doctor's troubles really begin, trying to adjust the blades under the body, with only a few minutes to go.

With this new type, forceps application is no more difficult than with ordinary cephalic position. Apply exactly the same method. The blades lock together with the thumb set. They cannot spring apart. There is no need to hold them by hand

grip and it is impossible to injure the head by hand pressure, because no matter how firmly you grip the handles there is positively no pressure on the blades. Grasp the middle of the curve with one hand and pull. The other hand pushes the top of the handles up and over the mother's abdomen as the head emerges. At the same time the baby's body is tilted up over the pubis to follow the forceps. Do not pull on the handles. That would tilt the blade tips up against the bladder. As this curve is maneuvered the face follows on the same principle as when we pull with a finger in the baby's mouth. This tilting brings the baby's mouth free at the vulva. There is no need to hurry now, because the baby can breathe, and there is no need to injure the neck or brachial plexus.

THE appendix of the child is larger in relation to the size of the abdominal cavity than is that of the adult, and the mesoappendix is correspondingly longer and less fixed. Therefore, the *point of maximal tenderness* may vary more in location than it does in the adult. It may appear near the midline, well down in the pelvis, or even out in the right flank.

From—"Abdominal Surgery of Infancy and Childhood"—by William E. Ladd and Robert E. Gross (W. B. Saunders Company).

A USEFUL AID IN THE MANAGEMENT OF COLOSTOMIES[*]

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THE care of a colostomy orifice has been greatly simplified in the past ten years, until now the average covering, is introduced into the stoma of the bowel to a distance just sufficient to leave enough of the outer paper tubing to
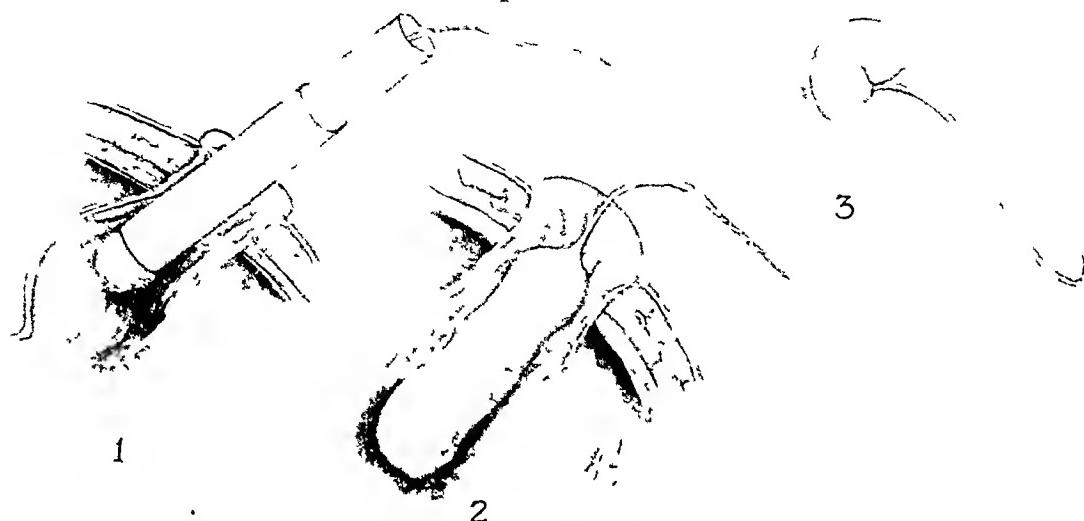
FIG. 1. 1, Tampon with outer covering being introduced into colostomy. 2, Tampon completely introduced. Outer covering has been removed. 3, Appearance of colostomy showing only attached cord protruding.

patient has little or no difficulty in handling a situation which formerly was greatly dreaded. The colostomy bag has been discarded by most surgeons, and in its place, simple pads, with proper training of the patient as to the care of the bowels, have made the so-called colostomy life anything but unpleasant to the patient and to those with whom he associates. Nevertheless, there is still much to be desired by the fastidious patient.

The useful aid to be described was devised by a very intelligent female patient of mine and, therefore, to her must and does go all the credit for its originality. A search of the literature fails to reveal any prior mention.

The accompanying illustrations show the technic of the device. The usual routine morning irrigation of the bowel is carried out. A vaginal tampax of appropriate size is selected. The tampax, with its outer

permit its withdrawal. Any protruding portion of the tampax is then further pushed into the opening until only the connecting string is left. A few layers of gauze or toilet paper over the colostomy complete the dressing. Under normal conditions, twenty-four hours may elapse before the dressing needs to be changed.

CONCLUSIONS

There is shown above, an inexpensive and most efficient aid for those obliged to lead a colostomy life. The normal moisture of the bowel causes the tampon to swell sufficiently to plug the colostomy firmly and prevent any involuntary passage of flatus. The device is comfortable and the originator, my patient, leads an entirely normal life and would not consent to go back to the type of dressing she formerly used.

Bookshelf Browsing

HUGH OWEN THOMAS*

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HUGH OWEN THOMAS was a most remarkable and interesting character, and a glimpse at his personality is as stimulating as a study of his professional achievements. He was born more than one hundred years ago in Wales. His father was a well established bone-setter practicing in Liverpool, the seventh in direct line of descent of followers of that work. At that time these practitioners, on the borderland of medicine, were not frowned upon as darkly as at present. Some of them were men of ability along certain lines, but their general knowledge of disease was very limited. Thomas said of them: "They knew nothing about diseases of the joints, and their treatment of joint disease was utterly wrong." That Thomas' father saw the doom of the bone-setters is evidenced by the fact that his five sons all became qualified surgeons. However, Thomas learned many things from his father who was a conservative and conscientious worker.

At the age of seventeen Owen Thomas was apprenticed to his uncle, Dr. Owen Roberts of Wales. Dr. Roberts was a cultured and capable physician and prepared young Thomas for Edinburgh. After two years there Thomas entered University College, London, and graduated in 1854, becoming a member of the Royal College of Surgeons. He then studied in Paris for a few months.

Thomas began practice as assistant to his father, and it was this connection that caused the medical men of Liverpool to consider him outside of the fold. Father and son, the former stubbornly conservative, the latter always imaginative, soon clashed and in 1858 Owen Thomas left his father and started practice independently. It was not long before he had a very considerable following, and opened the now famous office at 11 Nelson Street. Robert Jones used this office throughout his life, and it is now occupied by Mr. T. P. McMurray. This office was near the dock yards and warehouses, and from them Thomas received many cases of fractures and dislocations, so that he had ample material for observation of such injuries. The families of the workmen provided him with a large general practice. He labored constantly in their interest and no man ever had a more devoted and loyal following. He said one time that he "would rather treat a poor patient than a rich one, as the poor man added to his prestige while a rich man paid him a fee, but was not as apt to follow his instructions and thus ran away with his reputation."

Thomas had an original, investigative mind and was not content to take things for granted. Authority as such meant nothing to him unless authority's claims were proved by his own experience. Every case was a problem, and he labored to solve it with intense devotion. Robert Jones says of him that "he had an orderly mind and a prodigious memory," so he was well equipped to classify his cases and draw accurate conclusions as to his treatment. Added to this was his rare inventive genius,

* Address delivered at the Clinical Congress, New Haven, September, 1936.

which provided him with the apparatus to carry out his ideas. The *British Medical Journal* states that the appliances he invented and perfected have never been improved upon. One is impressed on looking through his books to find illustrated pieces of apparatus that are generally thought to be of recent origin. He seems to have anticipated everything in the way of splints and even the Balkan frame.

We generally think of Thomas as an orthopedic surgeon. As a matter of fact he carried on a general practice and had more than a local reputation as an operator for stone. Here again he devised an improved procedure and invented special instruments for carrying it out. He was one of the first to advocate the fresh air treatment of tuberculosis and he did pioneer work in the treatment of paralyzed muscles and nerve injuries.

Frederick Watson who has written "The Life of Sir Robert Jones," devotes considerable space to Dr. Thomas and says of him: "He knew more about diseases of the bones and joints than any living man, and had the largest practice of its kind in the world."

Thomas never had a public hospital appointment but his large practice provided him a wealth of material. He had a small hospital near his office, and on his own premises had a blacksmith shop and a smithy who made most of his apparatuses. The greatest part of his work was done in his office. Here fractures and dislocations were reduced, splints applied and the patients sent home. Robert Jones tells how Thomas would reduce old dislocations of the shoulder without an anesthetic, also of lithotomies performed with the patient lying on the office floor and without anesthesia, of seeing Thomas perform at least a thousand tenotomies for club foot, with as he says, what we would now consider most inadequate preparation, yet he never saw a case in which suppuration occurred.

Thomas was forever in search of basic principles upon which to establish his methods of treatment. He said, "To me it appears an anomaly that the surgeon should have to make a choice of theories. The principles of treatment should not be left to the discretion of the surgeon, but should be unalterable. The theory must first be settled and the mechanics will right themselves." To his mind the principle of rest was the dominant factor in recovery from disease, and his ingenious splints and braces were designed to carry out his idea most efficiently. He had been impressed while a student with the great number of amputations that were done for joint disease, and he set himself to devise a plan of treatment to cure the disease and save the limbs. His success in so doing is one of the most brilliant pages of surgical history. His well known splint is credited with saving innumerable limbs and lives during the World War. British Army statistics show that before the introduction of the Thomas splint 80 per cent of patients with compound fractures of the femur died. When immediate fixation in a Thomas splint was done Bowlby says this mortality was cut to 20 per cent.

In 1874, Thomas began experimenting to find a method of stimulating callus formation in cases of delayed union. At first he used percussion over the seat of fracture with a felt-padded hammer, but about 1880 he introduced a method that he called damming the circulation. He did this by tying pieces of rubber tubing above and below the fracture site. Sir Robert Jones tells of the visit of a famous German surgeon who was much interested in this form of treatment, and later published the method, but allowed his readers to infer that he was the originator of it. In 1889, Robert Jones reported forty-five cases of fracture of the neck of the femur that Dr. Thomas had treated by producing artificial impaction through pounding on the trochanter with a felt-protected mallet.

Dr. Thomas was accorded scant recognition by his British colleagues but his work attracted considerable attention in foreign countries and in the eighties he had many visitors from the continent and the U. S.

Those who saw his work and his results became firm followers of his teaching. The lack of appreciation at home may have been due in part to his association with his bone-setter father and his fearless attacks on false theories and practices no doubt also played their part. Always tolerant of criticism himself, he criticized outspokenly whatever he knew to be fallacious. In a criticism of Dr. Sayre's book he quotes from Dr. Sayre's preface: "It contains many expressions that I would like to change," and says, "It was Dr. Sayre's duty as a public teacher to change anything of the correctness of which he had a doubt." Thomas never published anything until he believed that he was on solid ground. The *British Medical Journal* states, "Of no man can it be more truly said that time has justified his teaching and practice." In a letter to Dr. Gibney he closes by saying, "I remain one able and contented to be weighed in the balance of the future." His severe criticism of nearly everyone may have been done in all honesty and was probably due to his burning zeal, but to call it blunt would be putting it mildly. Writing of the treatment of Madame Dudevant (George Sand) he says, "To this most painful, irrational, and useless procedure the elite of the profession in France were consenting parties, Madame Dudevant would have had a far better chance of recovery had no medical aid been sought for her." Discussing the report of a case of a child with intussusception treated by insufflation he wrote, "The child would have recovered sooner if no medical aid had been obtained—he luckily tided over both that and the local difficulty." Again he wrote, "Mr. Coley reports the operation, paracentesis, was performed with a trocar one sixth of an inch in diameter, but from the quality of the fluid that followed the gaseous discharge, it must have been one-fourth of an inch at least." Here without any personal knowledge of a performance he disputes the operator's report on the size of the instrument used. He was equally outspoken in his praise of anything that met with his approval. Speaking of a volume by Von Niemeyer he says, "No criticism of mine can do justice to its merits, nor to the trenchant manner with which he brings conviction to the mind of the reader." Of Sydenham, he says, "He seems to have come to the same conclusions as myself."

In 1873, Thomas published his first surgical work. This was on "Fractures of the Lower Jaw." The treatment he described and advocated is practically the same as that carried out today. To facilitate the operation he had devised an ingenious device for tightening or loosening the wire.

Rushton Parker became his friend and advised and encouraged him to publish his methods, so from 1873 until his death he published several books and many pamphlets, dealing with diseases and injuries to the bones and joints. At the time Thomas was working, Lister was perfecting his great innovation. Thomas wrote, "On the publication by Prof. Lister of his successes I at once commenced the practice of antiseptic surgery and continued to practice it with the result of being perfectly satisfied that its merits have not been overstated, nor the trouble necessary for carrying out the details exaggerated." Dr. Ridlon told me that while he saw Dr. Thomas working in clean aprons, one of the great hospital surgeons of England was using a discarded spring overcoat as an operating gown. This was only fifty years ago.

The amount of work done by Thomas is almost unbelievable. He told Dr. Gibney who visited him in the late eighties, that he saw one hundred patients a day, and two hundred on Sundays, a day he devoted to a free clinic. Dr. Ridlon who was the first American surgeon to visit Thomas counted 146 patients in the office in one day.

He showed evidence of careful reading of past as well as current medical writings and discussed them freely.

His intense interest and great industry is shown in the notes he made daily from the

newspaper reports of the illnesses of prominent persons. In the case of Leon Gambetta Thomas says, "His death was a subject of keen interest to the inhabitants of the civilized world." . . . He kept a chart of the patient's daily progress made up from the reports of Gambetta's physicians and in this chart Thomas discusses the treatment and gives his views as to its value. To quote, "Dec. 10. Further aggravation of abdominal symptoms, and during the night whilst M. Gambetti made an effort to visit the water closet, he felt a pain in the right hypograstic region, which hindered his sleeping and was present in the morning. This day Professor Charcot visited him and prescribed an anema; no tympany. It was proposed to apply counter-irritation to the seat of pain, but ultimately a laudanum compress was substituted.

"Dec. 31st. Night quiet, but low slight delirium, slightly conscious up to a quarter to 11 p.m. when he died." Thomas goes on, "The post mortem revealed the following facts—The termination of the ileum was found so much contracted that the finger could hardly be passed into it," etc., possibly a case of regional ileitis.

He likewise recorded the progress of President Garfield's illness keeping daily notes from "July 2nd. 1881 (mid-day) Pulse 52 time of accident but recovered to 63 shortly after, at 3 p.m. pulse 112, vomited 4:30." On September 19, he notes, "situation critical: chilled, pulse 143 feeble, towards evening pulse 104, temperature 91—Death."

When one of his horses became ill he took complete charge of its care, and recorded the daily symptoms and treatment in minute detail. To quote, "8th. day, 10 a.m.—Not in pain, as far as objective symptoms show; will not get up; had been lying some hours; got up at 10:30, but lay down again; now gave ten grains of morphia under the skin, and a gallon of oatmeal gruel; she also drank at 12 noon a bucketful of water, and rose up making signs for her usual food, and appeared all right. When lying down the skin of the abdomen was in folds, showing that there was no distention; pain returned. At 6 p.m. gave twelve grains of morphia. At 12 midnight gave fourteen grains of morphia—gave this large dose as the former doses appeared to lose their effect too soon. 15th. day, 10 a.m.—Found her on her back with very evident signs of pain. Some friends that were with me assured me she was dying; my previous experience informed me otherwise; gave twenty grains of morphia under skin; and in forty minutes she was up and apparently well. Her diet this day was limited to strong linseed tea and cold water, of which she took about a gallon. Twenty grains morphia repeated at 2 p.m., and again at 12 midnight, relieved all pain, so that during this day she gave no further signs of distress." This he kept up for thirty-four days and when his horse died, recorded the autopsy findings and then discussed the condition and progress of the disease with the results of treatment as compared to intestinal disease in the human. The completeness of these notes would do credit to any hospital records of today.

It is to Sir Robert Jones that we are indebted for most of our knowledge of Thomas' personality, and he was also instrumental in introducing Thomas' methods to the profession at large. Through his tact and ability he bridged the gulf between Thomas and his colleagues. Robert Jones was Thomas' nephew, and went to live with him at the age of fifteen. After graduating in medicine at twenty-one he joined his uncle as assistant at 11 Nelson Street in 1878, and was in intimate contact with him until Thomas' death. He refers to Thomas in the highest terms of affection and admiration.

In his Thomas Memorial Address Jones described a day's work of Dr. Thomas which sums up as follows: Starting at six he would make ten or twelve calls before breakfast. From nine to two he saw patients in his office. The afternoon was devoted to operating and visiting patients. After dinner he had patients till eight or nine.

His evenings were devoted to designing and making instruments or writing and reading. This routine Thomas kept up for over thirty years with never a vacation. To be always in action was his creed. How in the midst of such professional activity the man found time for other fields of endeavor is a mystery. Yet he was a student of history, theology and Egyptology and had some engineering knowledge. He was fond of music and devoted Sunday nights to home concerts.

Thomas was a slightly built man about 5 ft. 4 in. in height. He was never in robust health but seemed to carry on in spite of bodily ills. He was quick in his actions but exact in his work. Kind and generous, he was greatly loved and admired not only by his patients but by visiting doctors as well. He always wore a closely buttoned black coat and a peaked cap which protected an injured eye from the light. He smoked cigarettes almost constantly and kept a bureau drawer in his office filled with them.

Undoubtedly, Dr. Thomas shortened his life by overwork. He had often expressed to his wife the desire to die in harness and it was thus that he passed away. In January, 1891, he was attacked by pneumonia and died within a week. He was then fifty-seven years old. Robert Jones asks, "What might not such an active brain as his have developed had it been given longer life?"

It is generally acknowledged that Thomas has earned a place with the great surgeons of all times. His work speaks for itself, while the work of most of his contemporaries has been forgotten.

Editorial

THE TREATMENT OF GUNSHOT WOUNDS*

PRESIDENTIAL ADDRESS†

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TO discuss the subject of gunshot wounds properly, a volume of not inconsiderable proportions would be required. I believe, however, that it is possible to discuss wounds due to projectiles, as such, without specific reference to involvement of individual structures, such as the brain, lungs, heart, abdominal viscera and joints, since there are certain general principles which are applicable to the treatment of most, if not all, wounds of this sort. In order that my contribution may be kept within reasonable bounds the subject of burns shall not be discussed; nor shall the treatment of shock be considered. The two very interesting new phenomena of *blast* and *crush* cannot be discussed.

My justification for attempting to address you on this subject is based upon a prolonged experience during the first stage of the War. Commencing in June, 1915, I cared for wounded soldiers during a ten-year period. Of this time thirty months were spent at a Casualty Clearing Station, four months with Sir Robert Jones at Alder Hey, Liverpool, four months at a Base hospital in France and several years in charge of surgery at Ste. Anne's Military Hospital in Canada.

Since 1925, I have maintained my interest in wound protection and treatment and together with my colleague, Dr. L. H. McKim, have carried out intensive studies of the various technics which have from time to time been recommended. Every opportunity has been given to other members of my staff and to succeeding residents to treat wounds as seemed good to them, subject only to reasonable oversight. Since September 1939, both Dr. McKim and I have made every effort to keep in touch with such publications and memoranda as have become available particularly in the English literature. We have had, too, the very great pleasure of conferring with Dr. Philip Wilson whom the Association is so delighted to welcome as a guest at this meeting and from whom we hope to hear much of interest.

Most or all of the fellows know of the enthusiasm already expressed on more than one occasion by both Dr. McKim and myself with reference to the employment of B.I.P.P. and liquid paraffin;[1,2] if in this contribution comparatively little is said about this technic, I do not wish it to be understood that our views in this matter have undergone any modification.

As compared with what Bernard Shaw has called the Four Years' War, the present conflict has been comparatively trivial in so far as both the number of wounded and the nature of wounds are concerned. Up to May 23, 1941 figures relative to British losses in all fighting services and among civilians have been less than 175,000 persons including killed, wounded and prisoners. It is evident that the problem of the treatment of war wounds has still to be met by the medical services. Hitherto, as was the case in the Spanish war, the comparative ease with which the wounded have been handled, the early opportunity offered for careful mechanical treatment and the usual lack of necessity for rapid evacuation have made it possible for good results to be obtained without the exhibition of ancillary methods. These facts should not, however, lead us to the wishful conclusion that wounds such as we knew them during 1914 to 1918 will not be met with at a later date.

One of the major difficulties in speaking of war wounds is that the conditions under which they are suffered by the various members of the army, navy and air forces in this war as compared with those in the last war by civilians, vary so enormously. The variations depend, *inter alia,* upon the time of the year, the nature of the country particularly with reference to the character of the soil and the extent to which it has been cultivated, the character of the

military operations and the nature of the projectile inflicting the wound.

FACTORS WHICH INFLUENCE THE NATURE OF WOUNDS AND TYPE OF TREATMENT INDICATED

Micro-organisms and Gas Gangrene. Although in France and Flanders, particularly during the earlier years of the first stage of the war, practically all wounds were contaminated with the micro-organisms responsible for gas gangrene, this had not been the case in the South African War. During the war in Spain, too, this nightmare of the surgeon in France was largely absent. In so far as the British campaigns were concerned, during the first phase, the Mesopotamian force did not meet with this type of infection and in Gallipoli the incidence was relatively small. Hitherto, fortunately, in this war massive gas gangrene has not been prevalent.

Effect of Season upon Wounds and Wounded. In the summer the soil is relatively dry; the soldiers' clothing is relatively clean; shock accentuation due to chilling is minimal, and the roads are hard permitting rapid evacuation. During the winter the soil has turned to mud or slush; the soldiers' clothing is filthy; the lowering of body temperature deepens shock, and the roads are unfitted for rapid evacuation.

Character of Soil Affects Wounds. Dry sandy soil is free from infection and a delay in operating is not serious. Primary suture is indicated in such instances. Wet, highly fertilized soil teems with bacteria especially anaerobes: Clostridium and welchii œdematis maligni, Bacillus tetani and streptococci. A delay in operating is dangerous in the extreme and a primary suture is rarely indicated. A secondary suture is possible if the primary wound treatment has been adequate.

McNee and Dunn, in a series of twenty-five consecutive cases admitted to Casualty Clearing Station in the first British Army in France, and less than twenty-four hours old, found Bacillus aerogenes capsulatus in twenty-three cases and streptococci in nine. A. Fleming, in 1915, found Bacillus aerogenes capsulatus in 103 of 127 wounds of patients evacuated to England from France. These wounds were one to seven days old. In 102 cases streptococci were present.

Even in France and Flanders where, as indicated above, contamination with anaerobic bacteria was extremely widespread so that practically all wounds became more or less infected with the

Clostridium welchii, the bacillus of malignant edema and both aerobic and anaerobic streptococci, the incidence and gravity of these infections was much lower in the summer time than in the winter. This was due in all probability to the fact that in the winter time the soldiers' clothing was certain to be filthily contaminated with mud from the highly fertilized soil.

CHARACTER OF MILITARY OPERATIONS AFFECTS WOUND TREATMENT

The character of the military operations is of importance for several different reasons: In the first place, under what were spoken of during 1914 to 1918 as peace or quiet times in trench warfare most of the wounds were inflicted by hand grenades or trench mortars. Wounds by hand grenades were often comparatively trivial and the amount of tissue laceration due to such wounds was minimal, although frequently multiple. Wounds due to trench mortar projectiles were usually fatal at once since the high explosive charge carried by these bombs resulted in great destruction in their immediate neighborhood although, as the result of the irregular contour of the trenches, the neighbourhood affected by their activity was minimal. A comparable observation has been made by Broster[3] among air raid victims in Britain. Although the number of killed is almost equal to the number wounded, the majority of wounds, he states, are comparatively minor.

CLASSIFICATION OF WAR WOUNDS BASED UPON THE NATURE OF PROJECTILE

Rifle and Machine Gun Bullets. Their velocity is high; a small entrance is made and often a small exit unless the bullet is ricochet. These bullets perforate clothing and skin but often do not carry in any of the clothing. Heat may sterilize the wound which is favorable; centrifugal force causes necrosis of the cylinder of tissue and this is unfavorable. If reasonably early, such wounds may often be excised *en masse*, "bipped" and a primary suture employed. If a bone has been hit, a large exit wound and severe comminution result.

Although but few cases have been reported, Ross and Hulbert describe the care of a pilot officer who had his left humeral head shattered by a tracer bullet; the wound was still smoking when it was excised.

High Explosive Shell or Bomb (Aeroplane) Fragments and Trench Mortar Bombs. These cause severe mutilation and many complica-

tions; clothing and skin are carried into the depths of the wound and marked contusion and consequent devitalization of tissues occur. These shells are relatively slow moving and have little tendency to puncture but rather tear way into tissues. There is a wide variation in size and speed (momentum) of these projectiles; wounds differ much in character and extent.

Collapse of Dugouts, Houses, Shelters, etc. Serious injuries to head, spine, thorax and pelvis are common but often no open wounds are caused.

Shrapnel Balls. These are slow moving, blunt and are more likely to puncture than shell fragments or rifle or machine-gun bullets; they have a marked tendency to bounce.

Hand Grenades—Mills Bombs. The fragments are small and relatively slow moving (momentum low); they cause deep penetration not marked, but multiple wounds are common. Early removal is recommended and often primary suture with B.I.P.P.

When active military operations are in progress, it is more important that reinforcements and supplies get up to the fighting troops than that casualties be evacuated. Roads subjected as they are to artillery fire and bombing are necessarily employed for combatant purposes and delay in reception of wounded is inevitable.

When wounded are arriving at Casualty Clearing Station by the thousands in a few hours' time, evacuation to base must be accomplished as rapidly as transport is provided. All surgical intervention must, therefore, be of a nature that will absorb little time and the technic must render the wounded soldier as safe and comfortable as possible if many hours or days must elapse before further operating room treatment is available.

During battles, as for instance the battles of Vimy Ridge, Messines Ridge and Paschendaele, regarding which my knowledge is most intimate, the number of soldiers severely wounded who presented themselves for treatment at the Casualty Clearing stations made it absolutely impossible for the individual wounded to receive the necessary surgical intervention within a reasonable lapse of time.

PERSONNEL AND EQUIPMENT OF SURGICAL TEAM IN BRITISH
CASUALTY CLEARING STATIONS—1916 TO 1918

The personnel and equipment consisted of one surgeon, one anesthetist, one nursing sister, one o.r. corporal, one batman; one operating table, two complete sets of instruments, and a complete assortment of linen dressings and traction splints.

Although at our Casualty Clearing station we had received two reinforcing teams, making four teams in all, the situation created during the first twenty-four hours and longer of the battle of Vimy Ridge made it absolutely impossible to carry out adequate surgery. During the first twenty-four hours of this battle we received over three thousand stretcher cases and a larger number of ambulatory patients, the exact number of which we never checked up owing to our inability to supply clerks even to take their names. Of the three thousand or more stretcher patients at least two thousand deserved and required immediate surgical intervention. Enough has been said to indicate that this was impossible. As a matter of fact, during this battle within an hour after we commenced to receive the wounded we were forced to the decision that no head injuries would receive any attention. Within another hour the same decision was arrived at with regard to chest injuries and before three hours had elapsed it was decided that no patients with abdominal injuries would be operated upon. The soldiers, therefore, suffering from these three types of wounds were placed in marquees under the care of a single orderly whose only armamentarium was water and morphine.

Since the battle of Vimy Ridge commenced at daybreak in April, 1917, after a night of snow and sleet and with a temperature close to 32°F., all wounded were soaked with mud slush. Practically all stretcher cases were pale and pulseless and proved to have a body temperature too low to record on a clinical thermometer. Most had been wounded eight hours or a longer period prior to admission and, although they had received hot fluids, all were dehydrated and it was necessary to employ incandescent heaters and administer intravenous blood and glucose solutions before operation could be undertaken.

Later in the same year (1917) my team had the good fortune to work in the Second (British) Army during the battle of Messines Ridge with the First Australian Casualty Clearing station. During the first twenty-four hours of the battle we received two thousand wounded but owing to the fact that fourteen teams had been made available nearly 1,100 patients were operated upon in the one twenty-four-hour period. This was made possible by a method of classification which made it unnecessary for ten of the operating surgeons to see cases prior to operation and also because each surgeon working in this setup had two anesthetists and three operating tables. The number of wounded as compared with the number of

surgeons and adequacy of equipment, therefore, influences the delay which may occur after admission of the wounded.

Further examples of the necessity for all speed compatible with safety of life or limb could be given, but sufficient, however, has been said to indicate that military operations have a profound influence upon the nature of the surgery possible.

Under normal conditions in our civilian hospitals three aims are of paramount importance: (1) To save the life of the patient; (2) to discharge the patient with as little impairment of normal function as possible; (3) to obtain aims (1) and (2) with as short a loss of time to the patient, and with as little expense as possible due to stay in hospital.

Under battle conditions, when the number of surgeons and surgical teams available under the most favorable conditions is bound to be inadequate, there must be added to the above three desiderata an even more important item, namely, the adoption of a technic which will permit adequate treatment of as large a number of wounded soldiers as is possible in the shortest possible time.

As Sir Anthony Bowlby[4] said early in 1918, "If more primary sutures are to be carried out there must be more strong stretcher bearers and more surgeons." He also said, "If primary suture is to be employed rest for at least seven days without evacuation must be available." He placed himself on record as being an advocate of both B.I.P.P. and flavine.

As a preliminary to a consideration of a few of the proved methods of treating wounds it is, I believe, in order to make certain general remarks regarding both the operative procedures and the supplemental or ancillary methods to be employed following operation.

Operative procedures may be listed as follows: Radical incision of skin, subcutaneous tissue and fascia so as to permit: (A) Removal of foreign bodies: projectile, clothing, mud and gravel; (B) excision of devitalized and contaminated tissue (débridement); (C) careful exploration of all deep interstices, and (D) fixation to provide rest: traction, plaster of Paris.

It need not be urged here that the earlier operative interference is accomplished following injury the better the results are likely to be and the larger the proportion of primary sutures made possible. Enough has already been said to indicate that under battle conditions reasonably early operative interference is, as a rule, an impossibility. It may, however, be stated in general terms that operative

interference is carried out on the one hand in order to remove foreign bodies, projectiles, clothing, mud and gravel, or as in the case of air raid injuries, wood fragments of masonry and other portions of dwellings, and other buildings, and on the other hand to permit excision of devitalized and contaminated tissue which is likely to act as a culture medium from which bacteria, gangrene producing and other, are likely to invade the surrounding tissue.

Furthermore, at the completion of operative interference and the institution of whatever ancillary method is deemed advisable, the establishment of some method for adequate fixation is imperative. During the war of 1914 to 1918, the various methods of traction with the employment of Thomas splints and modifications thereof were most generally employed. It is possible, nay probable, that in the present war the application of plaster of Paris will be the more usual method of providing fixation particularly in so far as air raid wounds are concerned and those caused between battles. In this connection the importance of Trueta's observations in Spain cannot be minimized.

Although surgeons in many parts of the world were of the opinion in 1914 that they knew a good deal about the treatment of wounds, it soon became evident in France and Flanders that practically nothing was known about the handling of severe wounds due to the impact upon, and penetration of the tissues by projectiles. In most war wounds the lacerations are invariably complicated by an area of widespread contusion. In France and Flanders, moreover, practically all wounds were filthily contaminated with soil heavily loaded with excreta from both animals and man.

Up to the end of the Summer of 1915, the method of treating wounds was primitive on the one hand and disastrous on the other, and consisted for the most part in either no, or very inadequate, incision and the introduction of either rubber drainage tubes or a paste containing antiseptics. These antiseptics were forced into the deeper tissues through the wound made by the projectile. This procedure, as may well be realized, resulted in blocking of the wound so that secretions could not get out and in establishing the most perfect anaerobic conditions possible.

Gradually, on the part of all surgeons working at Casualty Clearing stations, disatisfaction with either of the above methods of treatment became evident, and in all Clearing stations one noted the more radical incision and then the excision of wounds. By the Spring of 1916 this more radical treatment had become generally used and

eusol (Edinburgh University solution) was being employed for lavage and the packing of wounds which had been incised and, in part, excised. In some cases in which anatomically it was possible to excise the track of the bullet completely this procedure was adopted, and in some of these cases primary suture was employed and was sometimes successful.

After adequate operative procedures have been carried out, in the great majority of battle wounds, most surgeons will feel the urge to supplement their operative interference by one or more of the ancillary procedures available.

A classification of supplemental methods of treatment of contaminated and infected wounds following operative procedures may be made under the following four headings: (1) The employment of antiseptics or germicides; (2) the employment of hydroscopic substances to stimulate lymphorrhea; (3) the employment of curtain drainage, and (4) the employment of agents capable of destroying necrotic tissue.

ANTISEPTICS OR GERMICIDES IN WOUND TREATMENT

Of the substances coming under the above heading which have been more generally employed and which have proved their usefulness under war conditions are: (1) Eusol and Dakin's solution—chlorine; (2) acriflavine, brilliant green and gentian violet—analine dye products; (3) alcohol, alcoholic iodine solution, ether; (4) iodoform and bismuth subnitrate; (5) sulfonamide group, and (6) potassium permanganate.

Although there is much evidence to support the thesis that the analine dyes mentioned are safe in proper dilutions and possess definite germicidal properties, time does not permit an adequate consideration of their merits. It must suffice for our purposes to quote from an article published early in 1918 by Pilcher and Hull:[5]

"For ease of preparation and application, rapidity when dealing with large numbers of cases, complete absence of surgical fidget, early cleaning of the wounds and abatement of constitutional reaction to absorption, flavine 1–1000 (and its cogener brilliant green) is an admirable application under all circumstances and especially when surgeons are few, time is short and wounds are many."

HYDROSCOPIC SUBSTANCES TO STIMULATE LYMPHORRHEA

There is much evidence to support the contention of Sir Almroth Wright that a tendency towards sterilization of wounds and a

stimulus to healing may be brought about by the technic which he has referred to as the "physiological method" of wound treatment. The essential feature of this technic is the application to the wound surface of substances which possess the property of stimulating discharge of tissue fluids and, also, interference with deposition of fibrine on the surface which to use Wright's expression, results in "lymphatic block." Wright, many years ago, introduced a hypertonic sodium chloride solution plus sodium citrate for this purpose.

Early during the war of 1914 to 1918, Colonel Gray introduced the salt pack. Further reference will be made to this technic in discussing the Reading bacillus.

The most active hydroscopic agent that I have employed is that of magnesium sulfate cream in glycerine as introduced by A. E. Morrison.

The general statement may be made regarding the hygroscopic agents that the possibility of extreme dehydration must be borne in mind and their use avoided over too large surfaces.

TECHNICS WHICH PERMIT AND INDUCE CURTAIN DRAINAGE

In order that our consideration of wound treatment may be complete it is necessary, I believe, to refer at least to the subject which may best be classified under the heading of agents which destroy necrotic material in the wound. Under battle conditions the urgency of safe though often inadequate operative treatment becomes imperative. The result may be, and often is, the necrosis of tissue in situ which has either been destroyed by the original wound or by bacterial activity later. When such a situation is met with the employment of the salt pack may prove life saving to many soldiers.

One major advantage of Gray's salt pack is that dressings need not be changed at an interval of less than from seven to ten days. This permitted evacuation of the wounded by train and boat with comparative safety and avoided the discomfort of frequent dressings. In 1917, J. L. Joyce who was stationed at Reading (Hampshire), noted that among patients treated by the salt pack who arrived at his hospital in the center of England the condition of the wounds could be estimated prior to the removal of dressings by the presence or absence of a foul odor. Rather surprisingly, it was noted in this connection that in those cases in which the odor was foul the condition of the wound was good, whereas in those cases in which the dressings were sweet the results were likely to be unfavorable.

Donaldson, a bacteriologist, examined these wounds and found that there was uniformly present in the cases that were doing well the presence of a spore-bearing proteolytic bacillus. This bacillus they were easily able to isolate in pure culture and gave it the name, Reading bacillus.

A large series of patients were treated by Donaldson and Joyce by means of either the salt pack or a pack composed of sphagnum-moss, the wound having been purposely contaminated with a pure culture of the Reading Bacillus. Their opinion, and there is much to support it, was that the nonpathogenic micro-organism assisted in the digestion of all devitalized tissue or slough in the wound.

In so far as I know, no one has carried out investigations in cases in which the occlusive plaster malodorous method was used as recommended by Orr and Trueta with a view to proving or disproving the presence of this spore-bearing proteolytic, nonpathogenic anaerobe. That this should not have been done is rather surprising.

Carrel-Dakin Technic.[1] During 1915 Dakin had introduced a hypochlorite solution comparable to, though more accurately standardized than, the Edinburgh University solution (eusol). Both depended for their usefulness as antiseptics upon the presence of sodium hypochlorite, and both had proved to have both *in vitro* and *in vivo* definite germicidal properties. At the same time, although normal tissues were not damaged, except for the skin, by the continued application of these solutions, both, but more particularly Dakin's solution, had the useful property of bringing about digestion or lysis of necrotic tissue and fibrin.

Late in 1915, Alexis Carrel went to France at the head of an American unit to assist the French in the care of the wounded and, more particularly, to carry out experiments which might lead to an improvement in wound treatment.

Carrel and his staff realized as had practically all Clearing station surgeons by that time that an essential feature of wound treatment must be wide incision and adequate excision of tissue. Furthermore, they introduced a definite and new method of wound treatment which became known by the descriptive expression "discontinuous irrigation with Dakin's solution."

Essentials of Carrel-Dakin Method. Operative: The essentials of the Carrel-Dakin operative method are: (1) Adequate incision and excision of devitalized tissue; (2) removal of foreign materials including, projectiles, clothing, and mud and gravel; and (3) fixation by traction.

Essentials of Carrel-Dakin Method. Discontinuous Irrigation: The technic of the Carrel-Dakin method of treatment is, I am sure, known to all. The essentials are, first wide incision and sufficient excision of tissue together with the removal of foreign bodies such as shell fragments, bullets, clothing material, and mud and gravel. After the wound has been so prepared that it is possible to examine adequately its deeper parts, small caliber rubber tubes, closed at the end but with multiple small openings close to the end on the sides of the tubes, are introduced into all the interstices of the wound toward the bottom. At hourly intervals Dakin's solution is run through the tubes thus reaching the bottom of the wound, and among other things washing out the wound from below. The action of the solution in addition to its mechanical one is due to its ability to bring about dissolution of dead tissue and fibrin and to the germicidal effect of the chlorine liberated.

Advantages of Carrel-Dakin Technic. The advantages are: (1) Adequate incision and removal of foreign bodies and damaged tissue; (2) wound lavage; (3) dissolution of sphacelus; (4) germicidal effect of chlorine, and (5) fixation

If the operative procedure has been adequately carried out, if the tubes have been positioned satisfactorily, and the discontinuous irrigation successfully attended to, there is no doubt that in most wounds substantial sterilization can be obtained so that secondary suture may be employed.

Disadvantages of Carrel-Dakin Technic. The main objection, particularly under battle conditions, to Carrel-Dakin's method, a method which received wide publicity and protagonism on this continent due in large measure to the enthusiasm of William O'Neil Sherman's[8] dynamic advocacy, is that the nursing care required for its successful employment is great. Although theoretically it would seem possible to prepare an automatic reservoir which would discharge the proper amount of fluid which would distribute itself into each of the many tubes in the wound, in practice this does not work out. In a case in which six or eight tubes have been introduced it is likely to be found that there is more back pressure on two or more of the tubes than on the remainder, with the result that that part of the wound served by the more or less occluded tubes does not receive its proper quota of solution. Under battle conditions, therefore, it was our invariable experience in France (at a Casualty Clearing station) that this method of treatment broke down and that it became in the individual case a somewhat dangerous trap.

Curtain Drainage. This term was introduced by Sir George Makins who was Consultant-in-Surgery in the Base area early in the course of the last war. He, however, did little to advance its usefulness; it remained as an ideal until the introduction of the B.I.P.P. method of treatment by Mr. Rutherford Morison.[9] Although Morison's original method provided but a thin film of liquid paraffin to the surfaces of a wound, it was not long before the supreme importance of the paraffin in the B.I.P.P. was recognized by a number of surgeons working in Clearing stations and in the British Home hospitals. The result was that in addition to the employment of Morison's original technic in order to facilitate and render safe either primary or secondary closure of wounds, it was found to be advisable in many cases of more seriously contaminated wounds to pack them widely open by means of large quantities of gauze soaked in liquid paraffin and to which a limited amount of B.I.P.P. had been added.

Rutherford Morison's B.I.P.P. Method. Before the end of 1915 Rutherford Morison stated that "disheartened by the results of treatment employed, I gradually developed a new method of dealing with infected wounds, which has been proven efficient."

It must be borne in mind in reading the above statement by Morison that his observation of war wounds had been confined to soldiers who have been evacuated to England (Northumberland) so that by the time cases reached him they were already infected and a more or less copious suppurating process had already been established. We are more concerned with the treatment of comparatively recent contaminated wounds as yet relatively free from suppuration and phlegmon.

After a trial of many antiseptics and vehicles Morison finally adopted as the most successful and the least toxic—bismuth-iodoform-paraffin paste. It should be stressed that Morison was primarily interested in curtain drainage and that he believed the essential constituent of the past to be paraffinum liquidum. It is evident that substitution of this substance by paraffinum molle (vaseline) hardly justified the claim of originality which at least one contributor has made. Since a paste which will adhere to the dehydrated tissues is required, it is important that liquid and not soft paraffin be employed if the effect originally planned by Morison is sought.

Since Morison's original aim was to permit safe closure (by suture) of suppurating wounds, it was essential that curtain drainage be obtained by means of a paste which would adhere to dehydrated tissues and so permit the paraffin to remain *in situ.*

RUTHERFORD MORISON'S B.I.P.P.

Bismuth subnitrate. .... 1 part
Powdered iodoform. .... 2 parts
Liquid paraffin...... .... about 1 part
    To make a paste which will adhere to dehydrated tissues.

Essentials of Rutherford Morison's Technic. The essentials of Morison's technic are: (1) Free exposure of whole wound including bottom and all interstices; (2) removal of foreign bodies and dead tissue; (3) hemostasis; (4) dehydration by means of alcohol; (5) careful application of B.I.P.P. to whole surface; (6) removal of all excess B.I.P.P.; (7) suture unless contraindicated, and (8) fixation splint or plaster.

An article by Colledge and Drummond[10] was one of the first published (July, 1917) regarding the employment of B.I.P.P. in the immediate treatment of wounds at a Casualty Clearing station. The technic described by Colledge and Drummond was typical of that used by most surgeons at Casualty Clearing stations. I believe that I cannot do better than quote from their article. It will be noted that at this time the addition of liquid paraffin soaked gauze had not been employed.

"The patients usually arrive in a filthy condition, encrusted with mud. The skin around the wounds, for now they are usually multiple shell, bomb, or grenade wounds, is cleaned with ether soap and rendered as surgically clean as possible. The part is surrounded with dry sterilized towels. Surrounding the entry and exit wounds there is always a margin of necrotic skin heavily infected with micro-organisms. This is removed by excising a ring of skin one-eighth of an inch wide. The wound is then freely opened up and all foreign bodies and loose pieces of bone are as far as possible removed. Further, all devitalized muscle is resected and bleeding points are secured with Spencer-Wells artery forceps. This resection extends not only to muscle which is obviously necrotic, but also to areas which are devascularised and non-contractile. It is in muscle in this condition that gas gangrene begins to spread. Although this procedure is most important, the writers have had long enough experience to know that in itself it is insufficient to prevent the subsequent development of obvious signs of infection in compound fractures.

"The raw surface is then well swabbed with methylated spirit, and the B.I.P.P. is smeared all over the wound and the ends of bone with a piece of dry gauze. It should be well rubbed in to form a thin film on the surface, and care should be taken not to leave any excess.

It is convenient to leave the ligaturing of bleeding points until this stage, as otherwise the ligatures are apt to be rubbed off. Gaps in muscle can be brought together with catgut stitches when necessary.

"The wound is then sewn up with interrupted fishing-gut sutures and a dressing of dry sterilized gauze is applied; this is covered with wool and a splint is applied. In a favourable case the dressing need not be disturbed until the patient is evacuated to the base. If the outer dressing becomes stained with discharge it should be changed without disturbing the gauze in contact with the wound. If the patient has to be evacuated immediately to the base it is advisable to insert the fishing-gut stitches, but to leave them untied or only loosely tied. They can then be tightened later on without fear of tension being caused in the wound by retained discharge. This applies particularly to very extensive wounds."

These authors, both of whom were personal friends in France, conclude with the following statements:

"The B.I.P.P. method is the simplest and most reliable the writers have had the opportunity of employing of avoiding suppuration in infected gunshot wounds.

"It contributes greatly to the comfort and well-being of the patient for the following reasons: (a) wet dressings and irrigations are avoided; (b) as the dressings need seldom be changed there is a minimum disturbance of the injured part.

"It greatly increases the facility and reduces the discomfort of transport. Apart from wounds of the viscera and central nervous system, the management of compound fractures presents the most difficult problem for the surgeon in a Casualty Clearing station, and it is in this class of cases that the writers have found the method particularly valuable."

Since McKim and I have already indicated our attitude with regard to Morison's paste and liquid paraffin gauze packing, no further reference to this form of curtain drainage will be made here.

Orr's Contribution. Perhaps the most generally publicized method of employing curtain drainage has been that modification of Morison's method with which the name of Orr is associated.

Orr substituted soft paraffin (vaseline) for the liquid paraffin introduced by Rutherford Morison and those who developed his method. Due probably to the occasional unfavorable developments as the result of iodoform or bismuth poisoning in cases in which B.I.P.P. was improperly used, he avoided the employment of an antiseptic. The foul odor which characterizes wounds treated in this

way is at least one result of the removal of bismuth and iodoform. Orr's technic depends upon three important principles: (1) Adequate mechanical (operative) treatment of the wound; (2) curtain drainage —soft paraffin packing, and (3) fixation—plaster of Paris.

There can be no doubt that Orr did, in fact, make a fundamental contribution in his insistence upon absolute fixation by the employment of plaster of Paris in older infected wounds. At the same time enough has been said, I believe, to indicate that in the opinion of many surgeons under battle conditions, in highly cultivated terrain, such a technic will require extremely careful judgment on the part of the surgeon employing it. It is, in fact, difficult for those of us who treated large numbers of wounded in France and became familiar with the horrors of gas gangrene to believe that methods of fixation other than traction by means of Thomas splints or one of the modifications thereof will be used when the battle period starts in the west.

Trueta's Contribution. During the Spanish War Trueta, of Barcelona, employed a method and has happily presented an adequate description of his technic to the surgical world and consequently to surgeons in the Medical Services of the army, navy and to those responsible for the care of air raid casualties. Since Trueta has published his technic in detail, together with the results obtained by him in over one thousand cases most of which were air raid casualties in Spain, it will not be necessary for me to describe his work in any detail.

Trueta's technic is essentially, I believe, summarized in the following way: (1) Adequate and somewhat radical mechanical (operative) treatment of the wound; (2) prevention of sealing of wound—gauze packing or rubber tubes, or both, and (3) application of unpadded plaster—usually moulded.

Trueta's contribution has shown more clearly, I believe, than ever before the importance of almost absolute fixation of the tissues, both bone and soft tissues, and prevention of edema in assisting them to control and limit the infective process.

However, I believe it should be borne in mind that Trueta's cases were chiefly air raid wounds, and that in consequence the length of time intervening between injury and surgical treatment was short; also, that the clothing and skin of such persons is relatively clean and that there is as a rule a minimal amount of mud and gravel contamination of wounds.

The reports that have arrived from Britain (Ross and Hulbert,[11] Cohen and Schulenburg,[12] Brown, Dennison, Ross and Divine)[13] regarding the employment of Trueta's technic in the case of air raid casualties, though as yet incomplete, would indicate that the method has proved its usefulness.

There are many laudatory reports from British surgeons regarding the value of Trueta's publications, and more especially regarding their appreciation of the contributions which Trueta is making to the present British war effort. I quote from remarks made by Sir Thomas Dunhill[14] who gave an account of sixty-five patients treated at his hospital, all of whom were regarded as extremely ill:

"They were patients whose knees and elbows were shattered and ankles broken. They were in a very unhappy condition on arrival; pus was soaking through the plaster to the beds, and the stench in the wards was beyond belief. In the last war he would have felt that three-quarters of these men would require to have their limbs amputated at once, and that streptococcal septicaemia would occur. There was no question of treating them in the Trueta fashion, but it was desired to see what fixation would do. Their condition was assessed as quickly as possible, the worst being dealt with quickly. Two died from secondary haemorrhage during the ensuing few weeks, and one from gas gangrene on the night he arrived; but apart from these three none of the sixty-five died. Their tongues were dry, their skin was the skin of poisoned people; they had no appetite and were in pain. A number got rigors, and when this occurred the plaster was taken off; if the drainage could be improved this was done, and the plaster reapplied. They all had a sulphonamide drug to begin with, which was stopped after a number of days when it was felt that the appropriate doses had been given. A good many times when rigor occurred he thought there was septicaemia, but it was not septicaemia, it was bacteriaemia, which he believed was controlled by the sulphonamide which was given. Often he thought that amputation should be done. Yet not one had died, all were walking with some kind of apparatus, and there were very few in whom the wounds had not dried completely. Their tongues were clean, their colour good, and their demeanour cheerful. There was no doubt that the haemolytic streptococcus had been there all the time, but it had been controlled. He believed the result to be, as to three-quarters of it, due to fixation, and, as to the remaining quarter, to the sulphonamide preparation, which, with fixation, seemed to be able to

scotch the spread of infection. In not one case was amputation done."

Sulfonamides. Since there was much evidence during the War of 1914 to 1918, and since further evidence has been accumulated in civilian practice since that time that a combination of infection by Bacillus aerogenes capsulatus (Clostridium welchii or perfringens) and Streptococcus hemolyticus is of greater importance than infection by either of these micro-organisms alone, and this both with reference to death of the individual and wound repair, and since sulfanilamide has proven itself to be of great importance in controlling streptococcal infections, it would seem evident that the proper administration of the latter drug must bear a prominent place in the treatment of wounds in this war. Whether the most suitable method of employment will prove to be per oram, local application or by the intravenous route must, I believe, continue to be considered *sub judice.*

In this connection, as well as others, I quote from a recent memorandum by Mr. W. H. Ogilvie,[15] of London. Ogilvie, in speaking of his clinical experiences after Dunkirk, said that most surgeons were thinking in terms of the last war; and when they considered how the present war differed from the last, infection seemed to be far less of a problem. The explanation was not so simple. The wounded were less tired and dehydrated; their clothes were cleaner, many of the weapons were far less damaging to the tissues than the shell and hand grenades which formed nearly the whole of the destructive armament of the last war. But after making these allowances much of the credit must go to chemotherapy.

This opinion was based on the observation of about 300 wounded, almost entirely from Dunkirk. Chemoprophylaxis when started early, unaccompanied by any form of treatment, put the cases into good condition, while those who arrived at the hospital infected, in whom chemotherapy was started immediately after operation quite early showed a state of repair and clean granulation which allowed of closure by approximation or grafting.

The wounded from Flanders and Dunkirk were seen never earlier than three days and most of them five days after being injured. Many had been operated on, others had relatively unimportant wounds and were fit to travel. Of the remainder there were two groups: those who had had sulfanilamide, and those who had not. About fifty had had sulfanilamide in varying doses; some had had it at once, others in transit; in some it had been continued regularly, in

many it had been irregular. But considering the late stage at which these cases arrived they were surprisingly fit and the infection of the wounds was minimal. The majority of the wounds were caused by bullets, the weather was dry, many were wounded in sand and on board ship; but even allowing for these circumstances, the contrast between these men and those who arrived at Rouen in 1918 was astounding, and the contrast between those who had been given a sulfonamide in transit and those who had not was almost equally so. The men who had had no sulfonamide drug and were admitted to the hospital two or three days after being wounded were most heavily infected. After being given a sulfonamide drug the patients had a temperature which rarely went above 100°F., and a pyemia which seldom lasted for more than three or four days. If it lasted for ten days, it was nearly always due to the pocketing of pus. Chemotherapy had, however, produced a new lesion, the "sulfonamide" abscess. It was a cold abscess, and when opened contained an odorless pus. The dose Mr. Ogilvie gave was three tablets, .5 Gm. crushed, to start with, followed by two tablets every four hours for forty-eight hours, and one tablet every four hours for the following forty-eight hours. Among the many wounded patients treated with this dosage there were no complications.

Colebrooke whose early work had much to do with the discovery of sulfanilamide and its action, in answering questions made certain memoranda. He said that he would hesitate to use more than 20 Gm. in a sulfanilamide pack, and he did not suppose there was any advantage in using more. For preventive purposes it was best to give one or two doses by mouth. He did not think protosil soluble had merits for quick absorption. If sulfanilamide was given in solution, it was absorbed in two or three hours. He had little to say with regard to sulfonamide ointments. Sulfanilamide was absorbed quite well from a greasy base. A question had been asked as to the treatment after putting on powder. At his hospital they simply powdered the wounds, and put on a moist saline dressing, covering it with jaconet. This was done to maintain the activity of the leucocytes, which was encouraged by keeping the wound slightly moist. Since Colebrooke is an advocate of sulfanilamide introduction into wounds his comments are, I believe, valuable.

We have not had sufficient experience in the use of the sulfonamides in wounds to warrant any opinion whatever. We have employed sulfonilamide prophylactically by mouth in all lacerated

wounds and some of the members of my staff have introduced it into wounds as a powder. No unfavorable effects have been noted.

CONCLUSIONS

In conclusion I wish to formulate our attitude toward the treatment of severe lacerated wounds whether associated with bone injury or complicated by lesions of other important structures, or not. These conclusions are based upon both personal experience and an effort to evaluate the contributions of other authors:

1. It must be urged that adequate, skilful, rapid operative treatment of the wound is of paramount importance. Such interference must remove foreign material and devitalized tissue and anticipate the development of interstitial tension.

2. Fixation must be obtained; the method adopted for this purpose will depend upon many variables. In general, it may be said that during battles traction should be employed but that for air raid victims and under other circumstances when early operation, leisurely surgery, and maintenance of casualties without evacuation for five days or more may be carried out, unpadded plaster of Paris is apparently safe and is perhaps to be preferred.

3. The prevention of edema and tension should be assisted by firm paraffin packing into the depths of wounds, the employment of pressure bandages or unpadded plasters and by posture. If plaster of Paris is used, windows must not be cut.

4. Bismuth-iodoform-paraffin paste is effective in controlling and preventing infection; it is safe and harmless if properly used and if too large surfaces are not exposed to its action. Of all the ancillary methods of wound treatment with which we are familiar, the employment of B.I.P.P. and liquid paraffin gauze packing is the most reliable, least dangerous and most easily applied.

5. One or other of the sulfonamides should be administered by mouth as a prophylactic and also in the treatment of established infection. The standardized precautions should be adhered to in their employment.

6. Both prophylactic and therapeutic employment of sera—antitetanic and antigangrene—is recommended. The necessity for the former among soldiers immunized to toxin is perhaps still unsettled.

REFERENCES

1. GURD, FRASER B. and MCKIM, LAURIE H. The use of B.I.P.P. and liquid paraffin in the treatment of wounds. *Am. J. Surg.*, 51: 584, 1941.

2. Gurd, Fraser B. and McKim, Laurie H. B.I.P.P. and liquid paraffin in the treatment of war and civilian wounds. *Ann. Surg.*, June, 1941 (in press).
3. Broster, Leonard R. Ad. Am. Surg. Ass., White Sulphur Springs, W. Va., April 29, 1941.
4. Bowlby, Sir Anthony. Primary suture of wounds at the front in France. *Brit. M. J.*, 1: 333, 1918.
5. Pilcher, E. M. and Hull, A. J. Treatment of wounds by flavine. *Brit. M. J.*, 1: 172, 1918.
6. Donaldson, Robert and Joyce, J. Leonard. A method of wound treatment by the introduction of living cultures of a spore-bearing anaerobe of the proteolytic group. *Lancet*, 2: 445, 1917.
7. Carrel, Alexis and Dehilly, G. The Treatment of Infected Wounds. London, 1917. Macmillan Co.
8. Sherman, Wm. O'Neil. Abortive treatment of wound treatment. *J. A. M. A.*, 69: 185, 1917.
9. Morison, Rutherford. Bipp Treatment of War Wounds. Oxford Primers. London, 1918. Frowde, Hodder & Stoughton.
10. Colledge, L. and Drummond, Hamilton. On the treatment of recent gunshot wounds with bismuth-iodoform-paraffin paste. *Lancet*, 2: 49, 1917.
11. Ross, James A. and Hulbert, K. F. Treatment of 100 war wounds and burns. *Brit. M. J.*, 1: 618, 1941.
12. Cohen, S. M. and Schulenburg, C. A. R. The treatment of war wounds of the limbs; experience in 266 cases. *Lancet*, 239: 351, 1940.
13. Brown, J. J. M., Dennison, W. M. Ross, J. A. and Divine, D. Experience at a casualty clearing station; operative procedure; wounds of the chest and abdomen; wounds of the head and eyes; burns; anesthesia. *Lancet*, 239: 443, 1940.
14. Dunhill, Sir Thomas. Proceedings Royal Society of Medicine. *Brit. M. J.*, 2: 642, 1940.
15. Ogilvie, W. H. Clinical experiences after Dunkirk. *Brit. M. J.*, 2: 643, 1940.

Note: The two following papers were also presented at the convention in May, 1941, but due to pressure of work could not be prepared in time for this issue: "Carpal Fractures as Seen in the Naval Service," by Commander F. R. Hook, U.S.N., Washington, D. C., and "Subcutaneous Traumatic Injury of the Abdominal Viscera," by Dr. Mims Gage, New Orleans, Louisiana.

Dr. Hook's paper was discussed by Dr. Laurie H. McKim, Dr. Preston A. Wade and Dr. Gordon Murray. Dr. Gage's paper was discussed in conjunction with the article by Dr. Palmer.

Original Articles

FRACTURES OF THE ELBOW

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NEW ORLEANS, LOUISIANA

D URING the past thirty years I have essayed many times to discuss experiences about fractures of the elbow. Methods change with improvement of technical details, with accumulated scientific data and with increased experience. Fundamental anatomic knowledge and physical principles remain unchanged.

It is probably more important for us to consider and to teach fundamental anatomic principles today than it was in the past. The ease with which one can resort to x-ray examinations gives many a false sense of security and predisposes to the habit of casting aside clinical examinations in favor of conclusions based on inadequate examinations.

Now that surgery of trauma is considered in its proper place there is an ever increasing desire on the part of competent surgeons to care for fractures rather than transfer the responsibility to the neophyte.

A discussion of fractures of the elbow should include epiphyseal fractures, supracondylar fractures, intercondylar fractures, fractures of the head of the radius, fractures of the olecranon, the coronoid process and fractures of the upper portion of the shaft of the ulna.

Basically, we must remember that in order for a joint to function normally there must not be any alteration in position of the articular surfaces which enter into the formation of the joint. Any change in the axis of an articular surface is bound to produce a partial or complete ankylosis of the joint.

There are four groups of elbow fractures which will regularly produce partial or complete ankylosis unless a definite effort is made from the onset to avoid such a disability. These are: (1) Fractures in children with displacement of an epiphysis; (2) supracondylar fractures, either comminuted or simple in which complete reduction is not accomplished; (3) fractures with displacement of a free fragment

which acts like a foreign body wedged between the articular surfaces. In this group we find fractures of the coronoid process, the internal condyle and fractures of the head of the radius; (4) fractures of the ulna, particularly, the upper third of the shaft.

In order to evaluate the significance of injuries about joints in children one must be familiar with the time of the appearance of various epiphyses, the time of fusion and complete ossification with the diaphysis, and the relative position of the epiphysis to the diaphysis.

Even though there has been for more than twenty years studies and pictorial monographs available for study and for teaching purposes, little attention is still paid to this subject in many schools. It is easy, if one is not familiar with the normal appearance, to consider that a fracture exists and the reverse is also true that misinterpretation often leads to the statement that "no fracture exists." The outstanding result is that too much dependence is placed upon the x-ray to the exclusion of clinical manifestations. *It is essential to maintain that the clinical examination is still of paramount importance in fractures about the elbow in children.*

In order to substantiate my statement that clinical examination is paramount it will be necessary to repeat statements which have been made many times before with reference to the appearance of the elbow in children.

The only epiphysis which is apparent prior to the fifth year is the capitellum. The relationship of the capitellum to the shaft and the sigmoid fossa of the olecranon alters definitely with approach to adolescense and adult life. In early life (up to the sixth year), a plane passed through the long axis of the middle shaft of the humerus lies behind the capitellum. As we approach complete development of the capitellum this plane either bisects the capitellum or two-thirds of it is anterior to the midplane.

Normally, in very young children there is a definite space between the capitellum and the sigmoid cavity. If there is an overlapping of the shadow of the capitellum by the sigmoid cavity, when the elbow is flexed at right angles, the implication is that there has been a fracture with displacement and, if union has occurred, there is vicious union.

The relationship of the internal epicondyle to the internal oblique line of the shaft of the humerus is of importance from a diagnostic standpoint. Normally, the internal epicondyle, which begins to ossify about the ninth year, is closely approximated and is continuous with

the internal oblique line. If there is a separation with displacement of the internal epicondyle, there has been a fracture. Under these conditions it acts as a foreign body and if it cannot be replaced removal is indicated. Removal of the internal epicondyle does not interfere with function of the elbow nor does it cause an alteration in the carrying angle if the structures about the elbow have not been injured.

A common source of confusion is the appearance of the epiphysis for the olecranon. It sometimes ossifies through two separate centers, more often, however, it ossifies through a single center. Ossification proceeds from the tip downward; the lower posterior aspect of the olecranon epiphysis is the last point of complete fusion. Not uncommonly one will find a report of a fracture of the olecranon which does not exist. These errors are due simply to the failure to interpret properly the normal appearance. The conclusion is inescapable that it is our duty to pay more attention to clinical examination and interpretation of the loss of function, localized pain and other objective phenomena than to depend solely on the x-ray.

Failure to reduce a deformity and restore the normal axis and relationship of the epiphysis to the diaphysis will result in ankylosis of the elbow. It is true that removal of an epiphysis, such as the epicondyle, is not desirable, but removal is preferable to an ankylosed elbow.

Operative intervention in fractures involving an epiphysis is not desirable because premature ossification results. Failure of the extremity to develop normally is certainly an undesirable result.

Supracondylar fractures form probably the largest group which we have to deal with among the injuries about the elbow in children. Immediate attention to these injuries is essential if we are to obtain the best results.

Early reduction, that is, within the first few hours, is of paramount importance. Delay means swelling, and this interferes with maintenance of the position of greatest stability.

It has been generally agreed for many years that the position of greatest stability is one of hyperflexion. In that position the triceps, the biceps and brachial anticus act as natural splints to maintain proper reduction. It is not sufficient to say hyperflexion alone. If the fracture involves the internal condyle, hyperflexion and complete pronation are indicated. If it involves the external articular surface, hyperflexion and supination are indicated.

There are several details which must be observed at this point. If hyperflexion interferes with the radial pulse, it cannot and should not be used. The danger of Volkmann's ischemia must be definitely considered.

Before entering into a discussion of the dangers of Volkmann's ischemia, a word about the dressing which has been utilized by us for many years may not be out of place. All bandages should extend from the finger tips to the shoulder. No splint is used in the bend of the elbow; a simple bandage, sheet wadding, bandaging the entire upper extremity as a stump is essential. Any bandage which begins at the wrist or ends at the wrist is dangerous. As swelling occurs a vicious circle results; the greater the swelling, the tighter the bandage, and more swelling of the hand will result. This can be definitely avoided by including the hand in all dressings and by avoiding the use of a gauze bandage sling, substituting for this a soft rubber tubing as a halter around the wrist and neck.

For more than twenty-five years it has been a practice with me to have a bag sling made to cover the dressing; this avoids the bandage slipping and permits free motion of the shoulder. It is important in these cases to begin shoulder motion from the earliest time, particularly rotation. Prolonged internal rotation at the shoulder permits contracture of the internal rotators and a stretching of the external rotators of the shoulder; and even though the patient has complete extension of the elbow, internal rotation at the shoulder causes the elbow to be held out thus giving a deformity which has nothing to do with the elbow injury. This deformity results from failure to give proper attention to the muscles about the shoulder girdle. There may be those who will disagree with this point. Personal experience has demonstrated the value of this detail.

Volkmann's ischemia, though not a frequent experience with most of us, is of such grave importance that when it does appear we should not overlook anything which might prevent this disastrous complication. It is preventable in most instances. There was a time when tight bandages were held responsible. Many theories have been advanced as to its etiology. Up to the present time no single etiologic factor has been demonstrated. Since the earliest manifestation may appear within the first few hours after the injury, it is important for the surgeon in attendance to be mindful of all of the factors which have been considered as possible provocative means for its production.

Volkmann, in his original description, expressed the belief that there was an interference with the arterial circulation thus robbing the muscles of oxygen and causing their death. He later indicated that he believed that there was in addition to an interference with the arterial blood supply an obstruction of the venous outflow.

Stephen Jones, of Boston, (1939) concludes *"Volkmann's ischemia occurs in the absence of splints or tight bandages." This conclusion is accepted by practically everyone.* He believes that it is caused in certain cases by interruption of circulation. He does not believe that it is due to a complete obstruction of a main artery. He bases this conclusion on the accepted fact that dry gangrene and flaccid paralysis result from obstruction of the main arterial supply. *He believes that the interruption of circulation or supply to the muscles may be due to intrinsic pressure upon the circulation caused by hemorrhage within the fascial envelope.* Based on this opinion he, with most others, believes that the operation of fasciotomy performed early gives an opportunity for collateral circulation to develop and avoids interference with oxygenation of the muscles which would result in the muscle changes characteristic of the condition.

Leriche advanced the idea that the condition was due to arterial spasm and accordingly advocated removal of sympathetic influences.

The outstanding studies of this subject have been made by Barney Brooks (1922) and by Griffiths (1940).

Before discussing these two studies it might be well to call attention to the fact that from the earliest period of investigation of Volkmann's ischemia certain facts with reference to the histologic findings have stood out. As early as 1884, Lesser, and again in 1907, Powers had occasion to study muscles removed from patients who had Volkmann's ischemia. *The outstanding findings were hyperplasia of connective tissue around and between muscle fibers and a marked inflammatory process in the muscle.*

In all Brooks' experimental work several things stand out plainly: "In no instance was there found marked inflammatory reaction or fibrous change in muscle in which permanent ligature of a large artery was done leaving the vein intact. In cases in which the vein alone was ligated, there was a marked inflammatory reaction evidenced by an accumulation of polymorphonuclear leucocytes and at a later stage large amounts of fibrous connective tissue were found.

"The result of the obstruction of the vein of the isolated muscles with the preservation of the artery is different from any result

obtained by artery occlusion. Under these conditions there was found a pathologic change, the outstanding features of which were hemorrhage, edema, degeneration of muscle fibers and an acute inflammatory process which progressed to a more or less complete fibrosis of the muscle.

"This fibrosis is associated with contraction and loss of power of the muscle. This process may convert the muscle into a veritable fibrous band which is incorporated in a similar fibrosis of the surrounding tissue. Permanent occlusion of a large artery is not followed by acute inflammatory disease. Anemia and inflammation are incompatable pathological processes. Any condition, therefore, which developes within twenty-four or forty-eight hours, and which is characterized by heat, swelling, pain and a subsequent fibrosis, cannot be the result of permanent occlusion of an artery. The classic picture of Volkmann's ischemia paralysis could only be explained on the basis of acute venous obstruction.'"

Middleton, in 1930, repeated experiments similar to Brooks and supported the views expressed by Brooks. Griffiths, in 1940, stated: "I cannot accept the conclusion that the lesion produced was a Volkmann's contracture."

Griffiths' clinical experience with Volkmann's ischemia is limited to a single case in which the patient was operated upon as early as the fourth day. The majority of cases which he saw were late cases. In the one four-day case there was no subfascial hemotoma. He is rather dogmatic in his statements: "The obstruction to venous return theory simply cannot stand." . . . "All the reports of early cases operated on in this country (England) and even elsewhere, the discovery of such a hemotoma is a very rare event. Instead what has been found by operators exploring early cases of Volkmann's syndrome is arterial obstruction."

Griffiths' statements are based on a rather extensive experience with cases after arterial injury and embolism. He has operated upon twenty patients in whom there has been an arterial occlusion due to embolism. "Three patients despite apparent successful restoration of the circulation developed typical Volkmann's ischemic contracture after embolectomy." He concludes as follows:

"Volkmann's contracture is due to arterial injury and reflex spasm."

Based on the above belief he advocates wide incision of fascia in the antecubital fossa and the adequate exposure of brachial, radial and ulna arteries in every case.

Garber and Steindler (1939 and 1936, respectively), have taken a very temperate view. Garber advocates fasciotomy and Steindler insists that one of the most important things in the avoidance of the condition is never to use a flexed position immediately after the accident.

There are two or three points which are important to us as teachers: Since there is a difference of opinion as to the etiologic factors in the production of this pathologic condition, it is essential that we try to avoid all of the possible causes.

With Volkmann's contracture in mind we should proceed with: (1) Early adequate reduction, prior to the onset of swelling; (2) avoid tight bandages; (3) if there is any interference with the radial pulse, acute flexion should not be used. That position in which one has an adequate radial pulse is the only position which is tenable. (4) If the swelling exists in the antecubital fossa and the radial pulse is absent, fasciotomy should be done. (5) I believe that it would be dangerous teaching to advocate exposure of radial, ulna and brachial arteries in these cases. These fractures are first seen by the general practitioner. If we advocate extensive exposure of major vessels, harm is bound to result.

American reports do not indicate that it has been necessary to expose the brachial artery after fasciotomy.

FRACTURES OF THE HEAD OF THE RADIUS

Fractures of the head of the radius are important injuries about the elbow because of three factors: (1) Many incomplete fractures of the head of the radius are overlooked and are considered as sprains or contusions of the elbow. (2) Fractures of the head of the radius in which there is a displacement require removal of the head of the radius. (3) Radial nerve paralysis is not infrequently associated with fractures of the head of the radius if there is an anterior dislocation of the radial head.

For the above reasons it is important to make a careful examination and to consider the possibility of a fracture of the head of the radius, even though no gross deformity exists, when there is limitation of pronation and supination and localized pain over the head of the radius. It is just as important for the future function of an elbow that immobilization be employed in such a case as if gross deformity existed. Such patients, if untreated, will experience some limitation of motion, particularly, pronation and supination, at a later date on account of exuberant callus which may be formed.

There are two important complications which result from displaced radial heads: The radial head acts as a wedge limiting motion of the elbow and the radial nerve may be stretched producing either temporary or permanent paralysis of its peripleral distribution.

The anatomic approach to the head of the radius so as to avoid injury to the radial nerve is urgent. Injury by stretching from unnecessary retraction is to be avoided just as assiduously as section through an improperly placed incision. Flexion of the elbow to a right angle and pronation of the forearm is the position which offers the greatest ease of approach to the radial head.

The fundamental principles outlined by James E. Thompson, of Galveston, Texas, for the approach to long bones should be observed. The incision for removal of the displaced radial head should be made so that the supinator muscle through which the radial nerve passes can be retracted forward. If there is any question as to the location of the nerve, dissection upward should be done so that the nerve can be seen prior to its penetration of the supination. (Further details of the approach are found in description of operation in Case 1.)

FRACTURES OF THE ULNA

Fractures of the upper third of the ulna must be considered when one is discussing fractures of the elbow. Attention has been called many times to the fact that anything which causes an alteration in the axis of one of the articular surfaces entering into the formation of a joint produces limitation of motion of that particular joint. This is especially true in fractures of the upper third of the ulna. In these fractures there is a definite pendulum swing of the upper fragment to the radial side. This is, in part, due to the contraction of the anconeus and supinator brevis which originate from the external condyle and are attached to the upper fragment of the ulna. The contraction of these muscles produces radial deviation of the upper fragment, which in turn is flexed by the brachialis anticus and biceps. The deviation thus produced alters the relationship of the sigmoid cavity to the articular surface of the humerus, thus limiting motion.

In order to have a normal functioning elbow following such an injury it is necessary that an anatomic reposition of fragments be obtained. This is one fracture which I believe definitely needs an open operation, as most of them cannot be reduced adequately by conservative measures. There are times when there is an associated fracture of the head of the radius with such fractures of the upper third of the ulna.

Operative Exposure. The operative exposure I have used for fifteen years follows: The method of approach consists of two separate incisions, if the upper ulna fragment is very short. The first is a linear and the other a semicircular incision which extends from one condyle to the other. The relation of the two is such that the linear incision meets the semicircular at its pole. When only the skin has been incised, the outline resembles a flag staff on a mound. At times a single posterolateral incision has been sufficient. The position of the forearm is important. The elbow is flexed and the forearm is midway between pronation and supination. This permits approach to the shaft of the ulna along the posterior ridge between the flexor profundus digitorum, extensor carpi ulnaris and anconeous. The shaft of the ulna is thus reached without injury to the muscles.

The semicircular flap of skin and superficial fascia is reflected. The muscles on either side of the linear incision are reflected and with them the radial and ulna nerves are retracted out of harm's way. The upper fragment which consists of the olecranon and the attached triceps is reflected slightly. The joint surface of the lower end of the humerus can then be exposed and with a retractor introduced the vessels in front of the elbow can be lifted up, permitting access to the front of the joint for the purpose of removing fragments of the head of the radius or of the coronoid. Retraction in this way avoids injury to the vessels which lie in front.

Other details relative to the particular method of approximating the fragments of the two ends of the fractured bone will be approached according to the particular habits of the operating surgeon.

The advantages of this incision are that it permits an approach to the joint without injury to important muscles or vessels and that it is not necessary to expose the nerves as they are retracted with the muscle.

If the ulna fragment is long, a single posterolateral incision is used. The technic is illustrated by the following case:

CASE 1. Mrs. E. K., age twenty-eight, was first seen by me May 18, 1933. On March 26, she had fallen on the outstretched hand and was immediately placed in the care of a surgeon who, the following day after manipulating the part under anesthesia, applied a plaster cast to the arm and forearm at a position of about 130 degrees. The cast was worn for about four weeks, after which it was cut in half and the arm was manipulated twice a week for three weeks, at the end of which time she was able to flex the elbow not beyond 120 degrees and extend it not beyond 150 degrees. There was complete loss of pronation and supination.

On examination atrophy of the arm and forearm was noted, a marked varus deformity of the elbow could be seen and there was a marked conical enlargement of the elbow with a fullness in the antecubital fossa. X-ray at this time showed an old fracture of the ulna with a pendulum swing to the radial side of the upper fragment, a fracture of the coronoid process and a fracture of the head of the radius with a free fragment just below the head of the radius. Preoperative Diagnosis: Fracture of the head of the radius and ulna—vicious union. Operation was done on May 26, 1933.

An incision was made over the ulna about four inches long, beginning just below the olecranon. The periosteum was retracted on the radial side and with it the aneoneous and supinator muscles. The radius was then seen and, subperiosteally, the shaft was displaced and brought into the wound and the orbicularis ligament was then cut and the head of the radius that was free was easily removed. The proximal end of the shaft was then smoothed off with rongeur and rasp and bone wax applied over the cut end. The ulna which we could see showed the site of the old fracture about one and one-half inches below the tip of the olecranon. There was an angulation of about 130 degrees between the upper fragment and the lower fragment. The union between these two fragments was very slight. The fragments were separated by the slightest bending movement of the fibrous tissue, and muscle on the anterior aspect of the upper fragment was separated from it. We also noticed a large piece of exuberant callus on the ulnar side of the distal fragment which was removed. We found another fracture of the sigmoid cavity and as we looked at the two fragments we realized that if we put a plate in with the screws, they would have to be extremely long, and more than that, a portion of the proximal fragment was so thin that the screws would have no definite hold on it. For that reason, it was decided to follow the plan I have adhered to before, using drill holes transversely, and particularly in the long axis of the bone in the upper and lower fragments. Iron wire was passed through and with U-sutures through both of these sets of drill holes the remains of the orbicular ligament was sutured to the posterior portion of the capsule. The fascia was approximated with interrupted chromic catgut. The skin was approximated with interrupted Burdick-Davis-Blair sutures and a plaster cast applied. Note: There was not a single large blood vessel injured in the whole procedure.

End Result. At the examination made May 10, 1941: "Patient is able to carry on her usual activities: playing golf, driving an automobile, swimming and rowing. She is able to extend the elbow to about 150 degrees and flex it to about 45 degrees. There is definite limitation of pronation and supination. X-ray picture taken at this time shows a synostosis—radius and ulna, and an old fracture of the ulna well healed."

X-ray Consultation, May 10, 1941. No. 69124: "Examination of the left elbow reveals evidence of old healed fractures of the olecranon, coronoid and upper radius. There is solid bone union. The olecranon is inclined

somewhat forward and at its base there is noted a wire loop embedded in the bone. A small step formation in the articular cortex identifies the site of the coranoid fracture. The articular cortex otherwise is smooth. The head of the radius has been removed, the proximal portion of the shaft being fused to the ulna. A bony ledge is seen to project anteriorly just below the coranoid process. The carrying angle is preserved."

Comment. Much time could have been saved and disability avoided if patient had been operated upon promptly.

Fractures of the lower end of the humerus in adults presents a very different problem from supracondylar fractures in children. The majority of supracondylar fractures in adults are of the flexion type and are often due to direct violence applied to the posterior aspect of the arm. There is often multiple comminutions as well as injury to the triceps muscle.

The method of treatment to be adopted in individual cases depends on several factors: notably the age of the patient, the amount of soft tissue damage at the time and the comminutions as well as displacements of fragments. It has not been my good fortune to be able to reduce these fragments and maintain reduction by the simple closed method in the majority of cases. Each case must be individualized. If there are multiple comminutions and displacements, direct skeletal traction (Kirschner wire) through the upper portion of the ulna just below the olecranon process in addition to suspension and lateral traction of the Russell type has been the primary method of choice. If reduction with this method cannot be satisfactorily obtained and maintained, open operation is indicated if the fragments are not too numerous.

In those cases in which open operation is advisable, I believe that the posterior approach as advocated by Van Gorder is the most desirable method of approach. It is true, it permits exposure of the entire posterior aspect of the shaft and the condyle with the minimum damage to important structures. It is advantageous because it avoids violent retraction. The procedure does not interfere with future flexion or extension of the elbow.

In order to illustrate the above statement a few cases will be briefly described and the method of treatment in each submitted.

CASE II. Mrs. E., age seventy-six, April 29, 1938, fell in her own home and struck the elbow from behind. Immediately there was loss of function and on examination there was a marked increased anteroposterior diameter of the right elbow and marked angulation of the lower portion of the arm. Immediately after preliminary inspection and palpation an x-ray was taken.

This revealed marked comminution of the lower end of the humerus, with the shaft of the humerus displaced downward between the fragments. The lateral view showed marked posterior displacement of the forearm with backward angulation and upward displacement of the forearm on the shaft of the humerus. It seemed evident that the only method available for this case would be direct skeletal traction. At once a Kirschner wire was introduced into the upper portion of the ulna, a sling was applied to the arm for the purpose of making use of suspension and traction of the Russell type. The forearm was suspended so that it would be as nearly as possible at right angles to the arm.

The progress of the case so far as the effect of the traction is concerned is illustrated by the x-ray pictures taken during the course of the treatment.

It seemed that any other operative intervention was not to be considered because of multiple fragmentation. The end result justified the method of treatment as the patient has almost (150°) complete extension and flexion beyond 45 degrees. The result is not perfect but it is better than I anticipated. It is better than any method that I know of for the management of such cases.

It is well for us at times to take stock and see what changes time has made in our method of handling individual cases and how much better results may have been obtained if we had handled an individual case in a different manner.

CASE III. Mr. N. O. B., age approximately forty, December 18, 1920, fell from a scaffold for a distance of twenty-five feet, sustained a compound fracture of the left humerus, laceration of the triceps tendon, lacerated scalp wound and a fracture of several ribs. The x-ray picture showed multiple comminuted fractures of the lower end of the humerus and the shaft was displaced downward between the external condyle and the trochlear process.

The immediate treatment at that time (1920) consisted of débridement of tendons and immobilization of the part in hyperflexion. Pictures taken the following day showed a displacement forward of the condyles and the lower fragment and an increase in the overridding deformity. Noting this displacement a Jones elbow extension splint was applied with a pressure pad on the forearm for the purpose of obtaining traction and if possible increasing the distance between the shaft and the distal fragments.

By March, 1921, he was able to extend the forearm on the arm at 160 degrees with a posterior angulation and considerable limitation of motion of the elbow. About one year later December, 1921, an arthroplasty was done. The technic was that suggested by MacAusland of Boston. A better functional result was obtained by the arthroplasty than the patient had prior to the operation.

In looking back over this experience it is easy to see how this patient may have been treated with comparative ease by introducing a Kirschner wire for skeletal traction and an overhead suspension as was used in the case of Mrs. E. This experience is introduced for the purpose of demonstrating the importance of changing methods with improvement.

CASE IV.   D., May 5, 1940, had suffered multiple comminuted supracondylar fractures. The patient was not admitted to Touro until about thirty-six hours after the accident because it occurred about six hundred miles from New Orleans. At once a Kirschner wire was introduced into the ulna and suspension of the Russell type of traction on the arm and suspension of the hand and forearm was applied. After ten days, when it was evident that it would be impossible by skeletal traction alone to accomplish anything like adequate anatomic reduction, it was decided to do an open operation. Preoperative diagnosis: Multiple comminuted fractures of the humerus with intercondylar fracture.

The posterior approach as suggested by Van Gorder was adopted. The patient was placed on her face with the arm resting on the table and forearm flexed at right angles with arm hanging over the side of the table. The incision was made over the posterior aspect of the arm from about five inches above the tip of the olecranon down to the level of the tip of the olecranon process. The skin and subcutaneous fat and fascia covering the triceps was incised. The ulnar nerve was exposed and retracted out of the way, then an inverted U-type of incision was made, the end beginning and ending about the level of the condyle and extending upward above the origin of the tendon triceps. This tongue-shaped flap of muscle and tendon was reflected downward, thus exposing the humerus. There was a great deal of old blood found in the depths. We then found the shaft of the humerus and the end of the proximal fragment was displaced down between the distal fragments. Our first effort was made to approximate the distal fragments and place a screw from the medial aspect to the lateral. This could not be definitely accomplished, because the thickness of the two condylar fragments was not great enough to hold the screws. Finally, we were compelled to put a plate on the shaft fragment and to approximate the shaft fragment and one of the distal fragments. There being nothing else for us to do, through a drill we held the lower fragments as well as we could with a piece of annealed iron wire. The internal condylar fracture seemed to be almost free. There were many small fragments and one or two being free had to be removed. The triceps muscle was then resutured and the skin and subcutaneous fat were sutured and a plaster cast applied with the elbow at right angles. A Kirschner wire was included in the cast.

The end result in this case was flexion to about 30 and 40 degrees and extension to about 170 degrees.

Summary of Supracondylar Fractures Where Comminution Exists.
(1) Skeletal traction is preferred rather than indirect skeletal traction with the use of adhesive plaster. If adhesive is used and the skin becomes irritated, the danger of surgical approach is definitely increased. (2) If anatomic reposition cannot be obtained and there are not too many comminutions, the use of either a screw or bolt to approximate the two condyles and in addition one or more plates applied from the shaft to the distal fragments is indicated. (3) These are definitely complicated fractures and the treatment had best be undertaken only if one has proper conditions for the treatment.

CONCLUSIONS

1. In the diagnosis of injuries about the elbow clinical examination should be accorded first place.

2. A false sense of security often results from x-ray examinations of elbow injuries especially in children.

3. It is essential to know the date of appearance, the relationship of and the age of complete ossification of the epiphyses in children, if x-ray pictures are to be interpreted properly.

4. Alteration of the axis of one of the articular surfaces results in partial or complete ankylosis of the joint.

5. There are four groups of fractures about the elbow which produce partial or complete ankylosis unless reduction is accomplished. These are: (a) Fractures in children with displacement of an epiphysis; (b) supracondylar fractures, either comminuted or simple, in which complete reduction is not accomplished; (c) fractures with displacement of a free fragment which acts like a foreign body wedged between the articular surfaces; (d) fractures of the ulna, particularly the upper third of the shaft.

6. Operation about the elbow involving the epiphyses should be avoided if possible in children.

7. If fractures of the internal epicondyle epiphysis cannot be completely reduced, its removal does not cause disturbance of function of the elbow.

8. Early complete reduction in fractures about the elbow is essential.

9. Every effort should be made to avoid Volkmann's ischemia. If there is evidence of hemorrhage about the joint, fasciotomy should be done. Exposure of the radial, ulna, or brachial arteries is not advocated in suspected cases of Volkmann's ischemia.

10. Fractures of the head of the radius with displacement of the radial head as a rule require resection of the head.

11. Radial nerve paralysis from stretching in cases of fractures of the head of the radius with displacement not uncommonly is a complication of these injuries.

12. A method of exposure for removal of the radial head is described.

13. Fractures of the upper third of the ulna are often associated with a pendulum swing of the upper fragments with a resultant diminution in the carrying angle and partial ankylosis of the elbow.

14. Operation is indicated in many of these cases.

15. Fractures of the head of the radius and fractures of the upper fifth of the ulna are commonly found as associate injuries.

16. The method of operative approach is indicated.

17. Comminuted, supracondylar fractures in adults are not uncommonly associated with a lacerated or a completely severed triceps tendon.

18. The method of treatment to be adopted in individual cases is dependent upon the age of the patient, the amount of soft tissue damage and the comminutions as well as the displacement of fragments.

19. Where there are multiple comminutions, skeletal traction making use of Kirschner wire in the upper portion of the ulna just below the olecranon for lateral traction and suspension, along a modified Russell plan is indicated.

20. If complete reduction cannot be accomplished and there are not too many fragments, operation making use of screws and plates is indicated.

21. Postoperative management includes immobilization until callus is sufficiently formed to allow for active motion.

22. Passive motion is a dangerous procedure.

23. Many forms of physiotherapy are harmful. Heat and gentle massage, plus active motion are the most important procedures to be adopted.

24. The method of approach for operation in comminuted supracondylar fractures suggested by Von Gorder offers the most direct approach and the least damage to anatomic structures.

BIBLIOGRAPHY

Cohn, Isidore. Observations on the normally developing elbow. *Arch. Surg.*, 2: 455–492, 1921.

Idem. Lesions of the epiphyses. *Am. J. Surg.*, 44: 279–281, 1939.

Idem. Observations based on a study of injuries to the elbow. *Arch. Surg.*, 3: 357–394, 1921.

Idem. Ankylosis of the elbow: its prevention and treatment. *South. M. J.* 17: 511–522, 1924.

Idem. Personal observations on fractures about the elbow. *Oklahoma S. M. J.*, March, 1934.

Idem. Contusions and sprains. 21: 97–105, 1928.

Idem. Fractures of the upper third of the ulna. 20: 585–394, 1927.

Idem. A fracture clinic. *Arch. Surg.*, 10: 163–184, 1925.

Idem. Controversial questions in the management of fractures. *South. M. J.*, 32: 879–882, 1939.

Idem. Normal bones and joints. Monograph. *Ann. Roentgenol.*, vol. 4, 1924.

STEINDLER, ARTHUR. Ischemic contracture. *Surg., Gynec. & Obst.*, 62: 358–362, 1936.

BROOKS, BARNEY. An experimental study of Volkmann's ischemic paralysis. *Arch. Surg.*, No. 5, pp. 188–216, 1922.

GRIFFITHS, D. LL. Volkmann's ischaemic contracture. *Brit. J. Surg.*, 28: 239–259, 1940.

JONES, STEPHEN G. Volkmann's contracture. *Am. J. Surg.*, 43: 325–337, 1939.

Idem. Volkmann's contracture. *J. Bone & Joint Surg.*, 17: 649–655, 1935.

LERICHE, R. Surgery of the sympathetic system. Indications and results. *Ann. Surg.*, 88: 449, 1928.

Idem. Arterectomy. *Surg., Gynec. & Obst.*, 64: 149, 1937.

MIDDLETON, D. S. The pathology of congenital torticollis. *Brit. J. Surg.*, 18: 188, 202.

GARBER, J. N. Volkmann's contracture as a complication of fractures of the forearm and elbow. *J. Bone & Joint Surg.*, 21: 154–168, 1939.

DISCUSSION

ROBERT I. HARRIS (Toronto, Ontario): The field of Dr. Cohn's paper is so broad, and the individual problems so diverse and so important as to make discussion difficult. I propose, therefore, to limit my discussion to one or two of the problems associated with fractures about the elbow, and leave to others the discussion of other problems.

First with regard to the supracondylar fractures which occur in children, so important because they are so common, I agree with Dr. Cohn that reliance upon x-ray alone can lead one into a false position. I am sure Dr. Cohn would agree, also, that the use of x-ray is essential in the adequate treatment of fracture.

We cannot overlook the clinical evidences of injury to the elbow in children, no matter what the x-ray says; but when we have before us the child whose elbow is obviously injured, x-ray is an essential aid to our treatment both of the reduction and especially of our determination as to whether the reduction has been adequate.

I find myself in agreement with Dr. Cohn also in believing that if reduction can be attained before swelling has taken place, the accuracy of reduction is better, and the ease of the maintenance of that reduction also is better.

I must say, however, that in holding this opinion, I am in strong disagreement with some of my colleagues, colleagues of great experience, who believe that the danger of Volkmann's paralysis, when reduction is carried

out before swelling has taken place, is so great as to place the surgeon in an undefendable position should Volkmann's paralysis occur.

However, frequently one is faced with the situation in which reduction must be performed after swelling has occurred. We have not the opportunity of seeing the patient, and the swelling has occurred. That is a common problem which must be faced.

It is my experience, in such circumstances, that reduction in stages is eminently successful, that is to say, the fracture is reduced and the elbow flexed as far as possible in the presence of swelling, without interfering with circulation; and after an interval of several days the elbow is flexed further in order to secure and maintain adequate reduction. This may be carried out to a third stage, if necessary.

Volkmann's paralysis is of the utmost seriousness to the patient and to the surgeon. I think it should be stressed that it can occur without the application of splints or bandages or plaster of any sort. Twice in my experience I have seen Volkmann's paralysis occur in association with supracondylar fractures without the application of any form of apparatus.

On one occasion, this fact was sufficient to win for a colleague a suit for malpractice, the knowledge that Volkmann's paralysis can occur without the use of splints.

I believe that Griffiths' work must be accepted with reserve. It has not been our experience that arterial occlusion due to embolism or thrombosis is productive of ischemia. More work is needed on the problem of Volkmann's paralysis, either to confirm Barney Brooks' work, which I believe to be correct, or to throw more light upon the problem.

Dr. Cohn did not mention, at least specifically, the fracture of the upper third of the radius associated with anterior dislocation of the head of the radius, the so-called Monteggia's fracture, important though rare. It is important because we should realize its pathology and realize also that the dislocation at the head of the radius prevents the reduction of the fracture of the ulna, and the dislocation cannot be corrected usually without operation.

J. DEWEY BISGARD (Omaha, Nebr.): I want to mention in this discussion, fractures involving the epiphyses of the lower end of the humerus which are so likely to result in some growth disturbance, and as the arm continues to grow this disturbance will cause an alteration of the carrying angle increasing, decreasing or reversing it. Such deformities are usually insignificant but it is wise to warn the parents of the child that a disturbance in growth is likely to take place subsequently. As a result of the alteration of the carrying angle—as has occurred in a number of cases in which there has been a disturbance in growth—there may result many years later a delayed or late ulnar nerve paralysis.

FRANK P. STRICKLER (Louisville, Ky.): I think this is a very important subject and that we ought to have a little more discussion on it.

There is one phase of it that I want to bring up, especially in children. It is over-x-raying these children. I do not think you should lose sight of the fact that over-x-raying of these cases can produce a disturbance in the epiphyses with the resultant inhibitory effect on the growth of the extremity. I think we should bear this in mind. As far as I know, there is no radiologist who will tell you how much or how little you can x-ray these epiphyses without producing an undesirable effect on them.

Another thing I believe Dr. Cohn meant to bring out, but to me he did not make it clear, is that in the ischemic paralysis, the damage many times is produced by the injury itself, and you may develop ischemic paralysis in instances in which the surgeon has nothing in the world to do with it. The damage is produced in the blood vessels at the time of the injury, and you will get an ischemic paralysis whether you use splints or not, or no matter what type of treatment you employ.

I think we ought to consider this phase of ischemic paralysis and have it definitely in mind in all serious cases.

EVALUATION OF THE "HANGING CAST" AS A METHOD OF TREATING FRACTURES OF THE HUMERUS*

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THE effective treatment of fractures depends upon adherence to principles. Two general methods of treatment of fractures dominate our therapeutic approach, namely, (a) reduction of the fractured bone ends with immobilization which externally may include the joints above and below the fracture and (b) application of traction to the injured part preferably in a position of relaxation. All forms of good fracture treatment belong to one or the other of these types. Much confusion has resulted in consideration of the use of the "hanging cast" method of treatment of fractures of the humerus. Some of this has arisen because the use of a plaster cast suggests that it is a form of immobilization fixation type of treatment. Considered in this light it is obviously in violation of principles. It is, however, one of the best examples of the use of traction in the treatment of fractures, and the humerus of all bones particularly lends itself to this form of treatment.

Traction methods are not new or startling. The use of traction on the humerus is well exemplified by the familiar suspension and traction method of Blake and Bulkley and by the use of the Jones humerus traction splint, as well as the method recently described by Gurd.[1] Since 1933, when Caldwell[2] described the use of the "hanging cast" in the treatment of fractures of the humerus, several series of cases have been reported[3,4,5,6,7,8] all attesting to the efficacy of this form of treatment.

Although anatomic reposition and rigid immobilization produces excellent results in certain types of fractures, it is appreciated that these requirements are not immediately necessary in all fractures. In
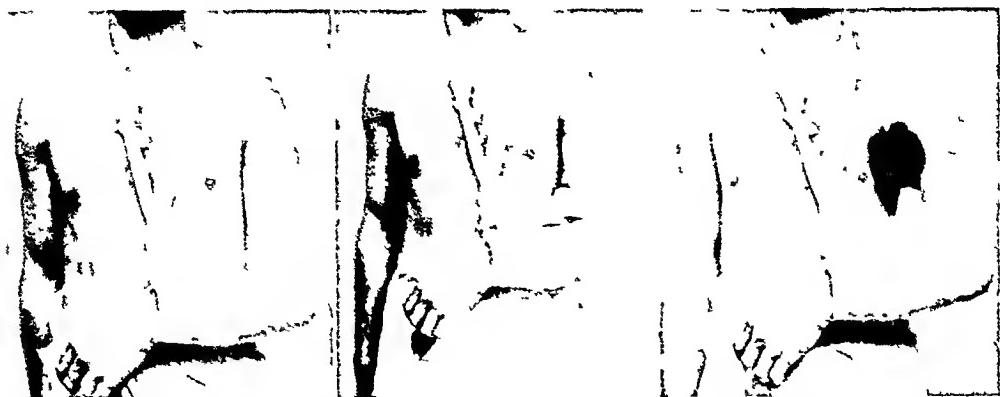
FIG. 1. "Hanging cast" showing plaster loop at base of thumb, neck sling attached, arm at right angle and wrist and shoulder free.

FIG. 2. Abduction pad placed at bend of elbow.

FIG. 3. Abduction pad placed higher on cast.

treating fractures of the femur, either by the Russell balanced traction method or by skeletal traction, a considerable degree of mobility at the fracture site is expected and regardless of this excellent results are obtained. In addition fixation methods which restrict normal joint function or fix a limb in an unnatural position actually may retard a successful end result. In 1924, Russell[9] describing the balanced traction method of treatment for fractures of the femur, discussed and stressed the importance of applying traction to a fractured extremity which had been so placed that the muscles might assume their normal and accustomed positions. He specifically mentioned the displacement of the fragments of a fractured humerus by the deltoid muscle and stated that it is unnecessary and possibly harmful to seek realignment by the utilization of extreme and unnatural positions of the upper extremity. The normal human carries his arms hanging at the sides of the body; consequently this may be considered as the position of rest. If then, it is possible to treat a fracture with the arms so placed, it is logical to assume that the muscles become relaxed. When this relaxation is augmented by gentle traction, the displaced bone fragments are pushed and pulled into normal relationship.

Since 1935, at Detroit Receiving Hospital, it has been the practice whenever possible to treat all fractures of the shaft and upper third of the humerus in traction by utilizing a light plaster cast in

addition to the weight of the arm. The first series of fifty-eight cases was reported by LaFerte and Rosenbaum.[4] In all there have been approximately 350 cases in this hospital in which this treatment was used. The present report concerns all cases in a two-year period totalling 136 cases. This cast has been described previously by several authors.[2,3,4,5,6,7,8] Suffice it to say that a circular cast is applied to the injured arm covered by stockingette, with the elbow at a right angle. (Fig. 1.) Occasionally, the elbow is placed at a slightly more acute angle to help control anterior angulations in fractures of the lower shaft. The cast extends from just below the axillary folds to the wrist and occasionally the hand is included as far down as the metacarpo-phalangeal joint. A plaster loop, wire or tape is incorporated into the cast at the wrist to which a neck sling is attached. The forearm usually is held in mid-pronation but occasionally the position of extreme pronation or suppination is required. The cast averages two and one-half to three and one-half pounds in weight for an adult. In addition abduction pads may be incorporated into the inner side of the cast to correct angulations. (Figs. 2 and 3.) Anterior or posterior angulation can be corrected by adjusting the length of the sling.

The patient is advised to sleep in a semireclining position for the first few nights and, in addition, is cautioned not to support the cast at the elbow. The time spent by the ordinary ambulatory patient in the erect position affords a sufficient period for effective traction. Although crepitus can be felt by the patient, pain usually disappears after one to three days and the individual soon learns that greater comfort is obtained when the cast is hanging free. After three to seven days active and passive motion is started at the shoulder. This can be instituted by having the patient bend forward and then rotate the arm at the shoulder in ever increasing circles. It is advisable to check the position of the fragments at the end of the first week under fluoroscopic observation with the patient standing. Thereafter the arm should be checked every two weeks. It may be necessary to adjust the sling or to change the size and position of pads on the inner side of the cast during the course of observation. It has been found that this type of treatment can be used in dealing with almost any fracture of the humerus.

In certain types of fractures of the humerus more or less typical displacements occur, but in the majority the "hanging cast" will correct the deformity or hold alignment after a closed reduction has been performed. It is generally agreed that perfect end-to-end
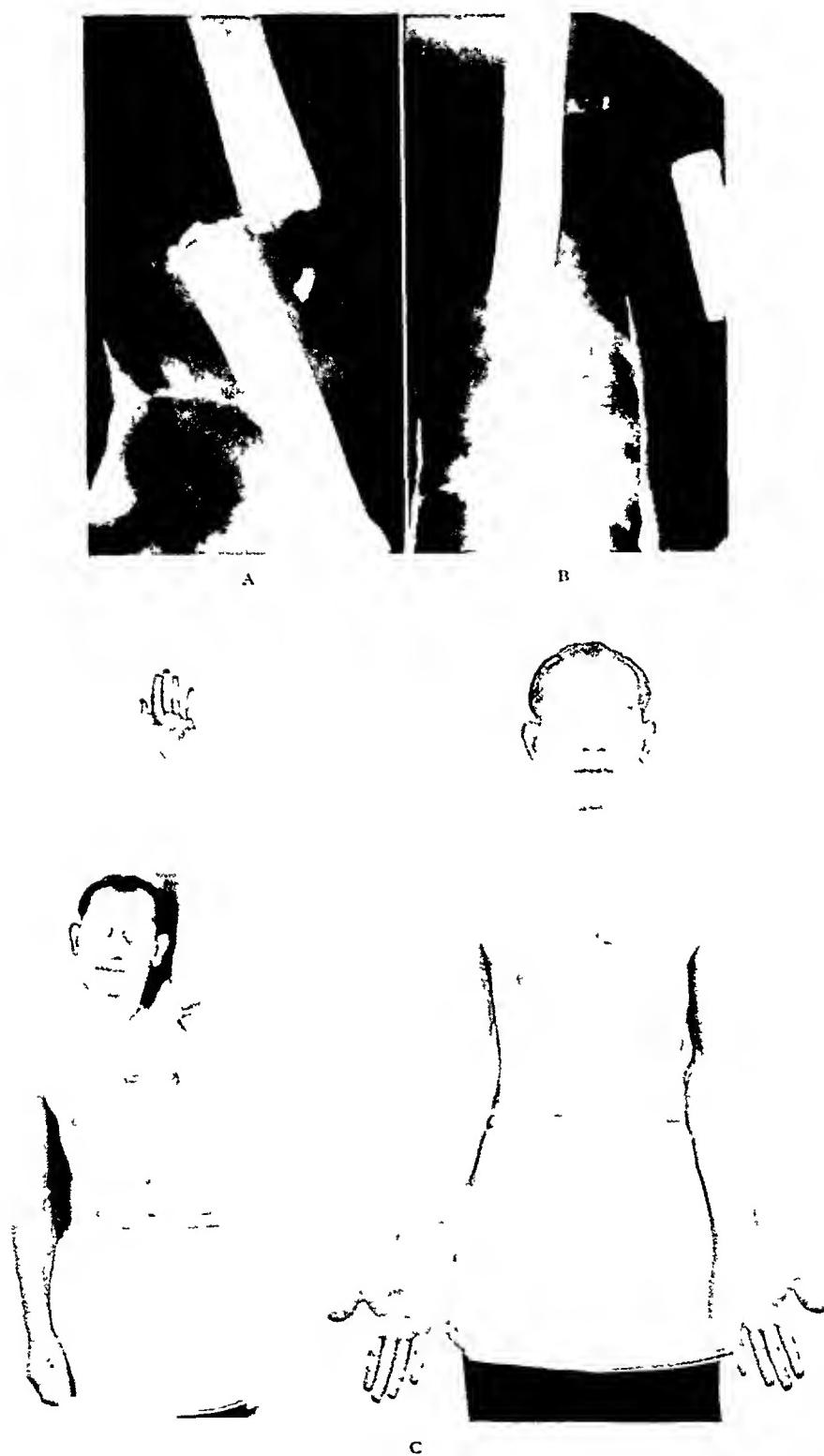
FIG. 4. A, anterior angulation; poor anatomic position; B, fair lateral position; C, perfect function, slight disturbance carrying angle and cosmetic result, two years later.

apposition of the fragments is not necessary for good functional results. (Fig. 4.) The question continually arises as to why internal rotation of the distal fragment in relation to the upper fragment does

FIG. 5. A, abduction and external rotation upper fragment with shortening and lateral angulation; B, correction lateral angulation and rotation; abduction pad used; C, shortening, angulation and rotation corrected, perfect anatomic and functional result, two and one-half months later.

not occur or persist. Apparently the muscles of the arm and primarily the biceps and the tendon of the long head rotate the upper fragment in the freely movable shoulder joint to correspond with the lower fragment.[10] (Fig. 5.) Fractures in the middle and lower third of the humerus have a tendency to assume a varus position. (Fig. 6.) This can be controlled by inserting a pad on the inner side of the cast at the bend of the elbow and for the lower shaft, by placing the forearm in a position of pronation, for supination increases the deformity as the joint is under the control of the pronators.[5] The great advantage of very free shoulder joint motion cannot be overemphasized and early mobilization can be realized without detriment to the result. The wrist is not included in the cast unless marked pronation is required and practically no stiffness occurs in this joint. In addition the continued use of the muscles of the upper arm and forearm, although limited, is quite considerable and the elbow joint does not seem to stiffen as it often does when placed in a rigid fixation apparatus. Obviously the reduction in the number of stiff or partially

stiff joints is important particularly in the older age groups. The degree of motion permitted by this method keeps the muscles in tone and permits of excellent blood supply, this latter undoubtedly being responsible largely for the reduction in the number of delayed and nonunion cases.

In addition it might be stated that we do not favor its use for true supracondylar fractures with posterior displacement, although we have utilized this method for the flexion type in adults. Griswold[5] has employed this method frequently with great success in this type of fracture. There may be a theoretic objection to the traction cast when dealing with severely comminuted fractures of the head, it having been pointed out that distraction and displacement may occur.[4] This has not been our experience. In badly displaced fractures of the surgical neck and upper one-third of the humerus, one should not expect the "hanging cast" to correct the displacement. Occasionally, however, correction is obtained. It has been our experience that these fractures with marked displacement are difficult to reduce by closed manipulation. Actually amazingly good functional results are obtained although the anatomic position is poor. Emphasis should be placed upon early mobilization and restoration of shoulder function rather than upon obtaining perfect anatomic reposition. Only occasionally does it seem justifiable to resort to open operation, as the results obtained by the "hanging cast" along conservative lines are so excellent.

Early in the use of this method it was our practice to reduce the fragments in shaft fractures by manipulation under anesthesia. This, however, is not now our general course of procedure as it has been found that simple alignment and the immediate application of a traction cast will produce excellent functional and satisfactory anatomic results. Care must be taken not to use too heavy a cast as distraction may be produced and this particularly applies to the transverse shaft fractures. Obviously, if the patient is confined to bed because of associated injuries the hanging cast cannot be used. In addition, we do not favor its use early in compound fractures, although it may be used here as a convalescent splint or as a continuation method of therapy. Theoretically, one might expect difficulty because of lack of co-operation with very young children. Nevertheless, we have not found this to be true, some of our best results having been obtained in children under ten.

The evaluation of the method should be made on the results obtained. The following analysis is based on 103 cases of the 122

A

B
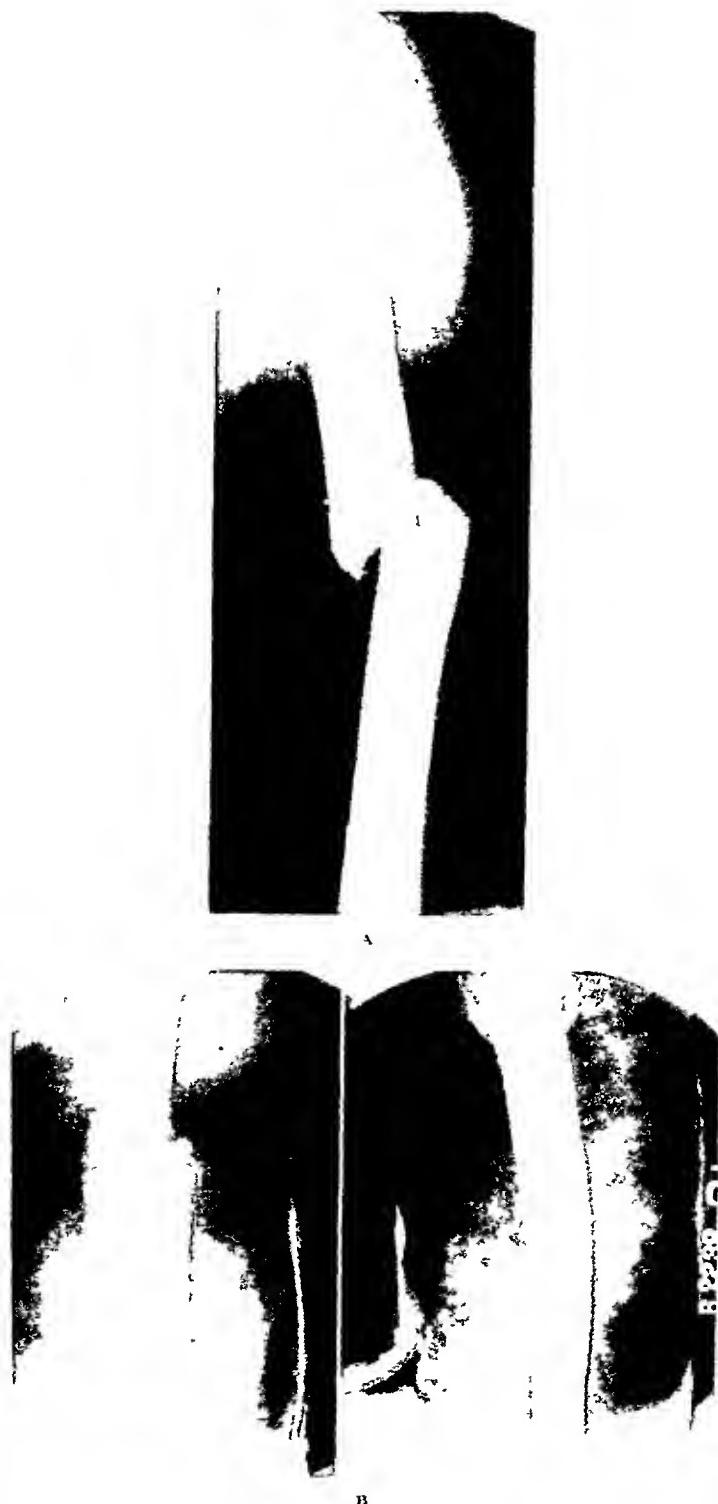
Fig. 6. For descriptive legend see opposite page

cases in which the "hanging cast" was used exclusively. We were unable to obtain complete follow-up data on nineteen cases although in several of these progress had been satisfactory. The patients have


c
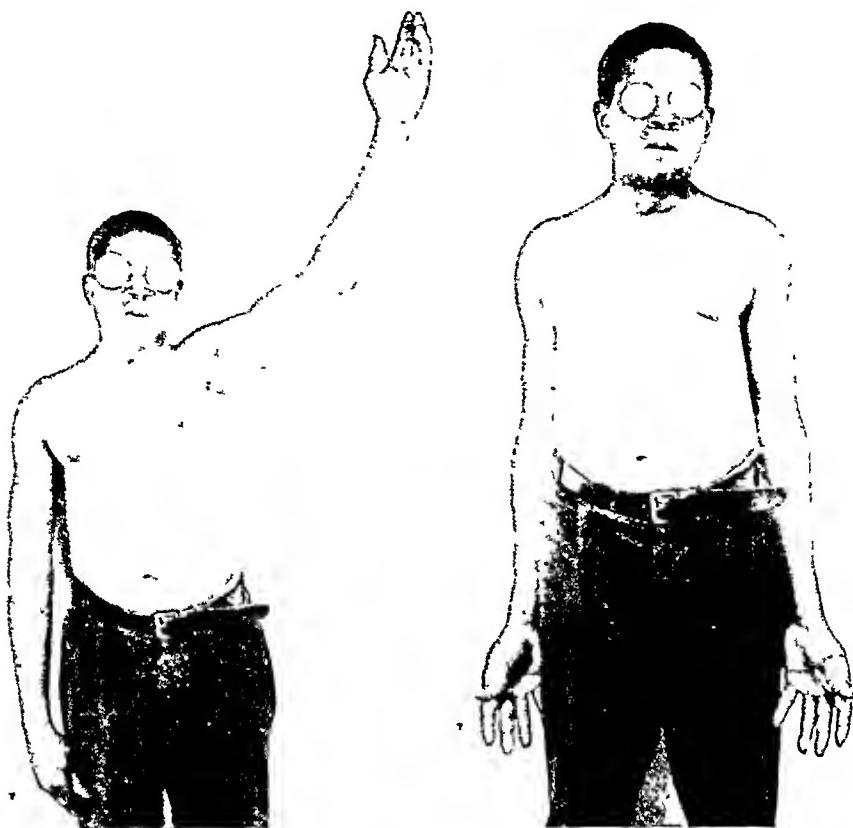
FIG. 6. A, lateral angulation and slight internal rotation lower fragment; B, good anatomic position; abduction pad used at elbow; c, excellent function; no deformity, two years later.

been seen for their final evaluation in from six weeks to two years after removal of the cast. In determining the final result we have used the qualifying terms, "excellent," "good," "fair," and "poor." By "excellent" we mean that function of the arm has returned essentially to its former normalcy. Perfect anatomic reposition as measured by the x-ray, although obtained in a large majority of instances, was not particularly sought after and it should be stated that there was little or no correlation between this and the functional result. Cosmetic results except in a few instances were uniformly excellent.

The lesions were grouped according to this classification: (1) fractures of the upper third of the humerus including the neck in (a) initially good or fair, and (b) poor position; (2) fractures of the middle

and lower third of the shaft in (*a*) initially good or fair and (*b*) poor position.

It will be seen in referring to Figure 7 that the age incidence was rather widely distributed. Of all of the five-year periods the greatest
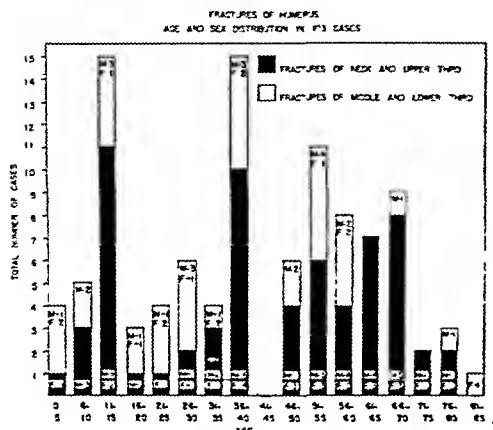

FIG. 7.
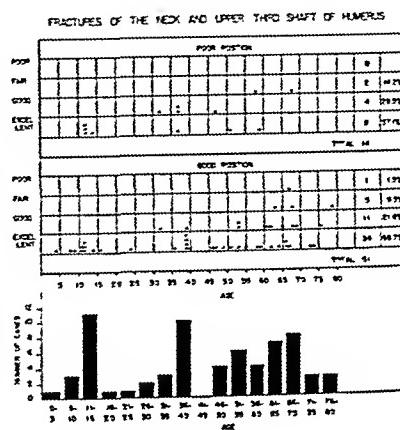
FIG. 8.

number of cases of both types occurred in the periods of eleven to fifteen years and thirty-six to forty years. In general, patients with injuries involving the upper portion of the humerus were slightly older than those suffering from fractures of the more distal shaft. There were more males than females in the series and there was little or no correlation between age and sex. A larger number of fractures occurred in the upper third of the shaft and neck than in the middle and lower one-third of the shaft of the humerus.

The functional results (Fig. 8) in the fractures of the neck and upper one-third of the humerus in initially poor, as well as good position show a tendency to be less satisfactory in the older age groups. Combined "excellent" and "good" results for the poor position group were obtained in 85.6 per cent and for the good position group in 88.3 per cent. In this entire group only one case, a sixty-seven year old female, obtained a "poor" functional result, abduction being limited to 50 degrees.

It is apparent from Figure 9 that the lower humeral fractures occur in a somewhat younger age group. Relatively, the younger age groups with distal shaft fractures received less satisfactory results than the same age groups with upper humeral fractures. More "excellent" results (77.3 per cent) were obtained in the middle and lower one third of the shaft fractures in good initial position than for those in poor position (42.9 per cent). However, the combined

percentage of "excellent" and "good" results was 80.6 per cent for those in good position and 85.8 per cent for those in poor position. In comparison the fractures of the lower humerus seem to produce slightly more disability than those of the upper shaft.
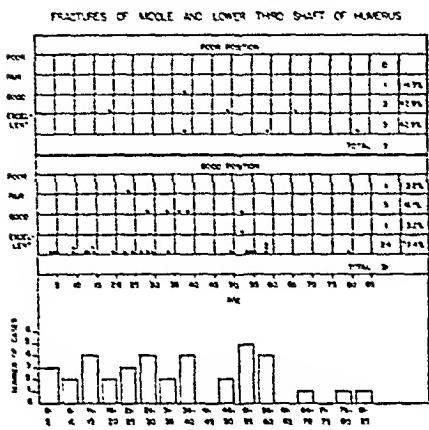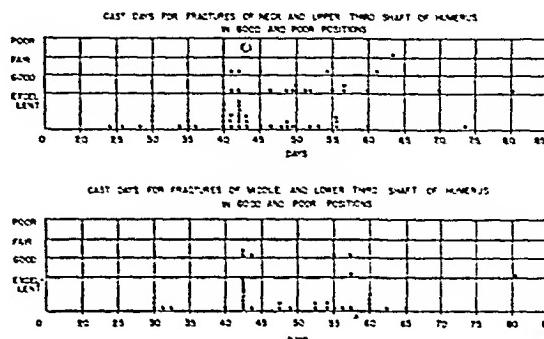
FIG. 9.   FIG. 10.

Again it should be pointed out that in this entire group of lower shaft fractures, it was considered that in only one a poor functional result was obtained (85 degrees limitation of shoulder motion, slight restriction of rotation and slight disturbance of carrying angle).

The number of cast days (Fig. 10) varied considerably but it is evident that in the majority removal was effected in the thirty-day to sixty-day period. The average number of cast days for the whole series was 47.5 days and this held essentially for the various types and locations of the fractures. There was little or no correlation between the number of days in the cast either of the age of the patient or end result. It might be stated that the use of the cast for six to nine weeks is slightly longer than that reported by previous authors. We have no definite explanation for this except that of conservatism and also as we believe that the slight prolongation of the time in the hanging cast does not particularly effect a rapid functional recovery.

In the entire group of 103 cases shoulder function was estimated as excellent in sixty-nine cases, good in nineteen cases, fair in thirteen cases and poor in two cases; a combined percentage of excellent and good results of 85.4 per cent. The usual disturbance though slight was mild limitation of abduction and in only three instances was there restriction of rotation.

Function of the elbow joint was but mildly disturbed in five cases, two of these having slight decrease in the carrying angle and one a

slight increase, while of the remaining two cases, one had 10 degrees limitation of extension and one had between 10 and 15 degrees limitation of full flexion. These cases, however, were considered to have "good" function.

Nerve injury occurred in four cases, one median and one radial in the upper humeral fractures and two radials in the lower shaft lesions. Two of these were explored and all had perfect return of function.

There was one case of delayed union. This thirty-eight year old female patient had a severely comminuted, oblique fracture in the supracondylar area and lower one-third of the shaft. Marked varus deformity persisted for several days and there was delay in correcting this by pronation of the forearm.

Although there was sufficient union to remove the cast in sixty days, the degree and solidity was questioned for thirty days more. The general result was excellent, with only a barely perceptible disturbance of the carrying angle.

One nonunion occurred in a fifty-two year old negro female who had sustained a transverse fracture at the junction of the middle and upper one-third of the shaft of the humerus. This patient was an alcoholic in poor general condition. At the end of five months, fibrous union with some evidence of a pseudo-arthrosis was present. The general functional result, however, was fair. Operation was advised but the patient refused, and no further follow-up could be obtained.

Physiotherapy was used in twenty-two cases of the 103.

Closed manipulation under anesthesia was performed in seven cases, only one of these having a lower shaft fracture. However, there were a considerable number of cases in which simple alignment of the fragments was carried out without anesthesia. Open reduction was resorted to in one case immediately and postoperative treatment by "hanging cast" traction produced an excellent result.

It was necessary to hospitalize twenty-one cases for periods varying from one to sixteen days, thirteen of these patients remaining in the hospital under six days. Of the twenty-one cases, thirteen required hospitalization because of associated injuries and eight were observed for a short period because of the degree of trauma to the soft tissues of the arm.

In addition to the 103 cases in which the "hanging cast" was used exclusively as the treatment of choice, there was a group of fourteen cases in which the traction cast together with other types of traction and fixation was utilized. These cases were not included in

the complete analysis as it was impossible to evaluate accurately, the importance of any one method. Six of these cases were compound fractures which were initially treated by operative procedures; skeletal and other forms of traction. The "hanging cast" was applied as a continuation or convalescent splint in from four days to six weeks after the primary treatment. All of these patients obtained satisfactory results.

The remaining eight cases were hospitalized because of associated skeletal or soft tissue injuries and were first treated by other traction methods, the "hanging cast" being used six to twenty-four days later to supplement the therapy. These individuals also received satisfactory results.

These latter cases emphasize the value of the "hanging cast" as a method of adjunct or convalescent treatment.

SUMMARY

1. The method does not depart from established principles as widely as is generally supposed.

2. It is applicable to most fractures of the humerus.

3. It is cheap, simple and easy to apply.

4. It is comfortable.

5. The method permits the patient to be ambulatory and allows early mobilization of joints.

6. The number of hospital days and the amount of physiotherapy are reduced to a minimum.

7. The incidence of delayed and nonunion is very low.

8. The end results, particularly as to function, are equal to or better than those obtained by other methods.

In conclusion, we believe that the "hanging cast" method of treatment for fractures of the humerus is most effective and should be given a prominent position in the list of the various forms of therapy utilized for these lesions.

REFERENCES

1. Gurd, Fraser B. Am. J. Surg., 47: 443–453, 1940.
2. Caldwell, John A. Ann. Surg., 97: 161–176, 1933.
3. Rush, L. V. and Rush, H. L. Soutb. Surg., 1: 325–327, 1933.
4. LaFerte, A. D. and Rosenbaum, M. G. Surg., Gynec. & Obst., 65: 231–237, 1937.
5. Griswold, R. Arnold, Goldberg, Harry, and Joplin, Robertson. Am. J. Surg., 43: 31–38, 1939.
6. Caldwell, John A. Surg., Gynec. & Obst., 70: 421–425, 1940.
7. North, John Paul. Surg. Clin. N. America, 20: 1633–1643, 1940.

8. HUDSON, R. T. *South. Surg.*, 10: 132–134, 1941.
9. RUSSELL, R. HAMILTON. *Brit. J. Surg.*, 11: 491–502, 1924.
10. HOWARD, NELSON, J. and ELOESSER, LEO. *J. Bone & Joint Surg.*, 16: 1–29, 1934.

DISCUSSION

A. D. LaFERTÉ (Detroit, Mich.): In continuing for a moment this discussion, there are just one or two things I should like to add to what Dr. Winfield has said.

We started the use of the hanging cast in 1935 because of the fact that the patients we were treating were having such disability in the shoulder joint, such great muscle atrophy.

I was impressed on being called to see one big, husky athlete who had had a fracture and been put in one of these stock abduction splints. He had an anterior angulation, and he had such atrophy of the shoulder muscles of that side that we suspected a dislocation. The head of the bone stood out; you could pick it right up, while the opposite shoulder was very powerful.

In our meetings at Receiving Hospital on fracture discussion, we decided to try other methods, which we did. We found that this cast was giving us the best result, so from then on we have used this hanging cast a great deal.

One other thing I should like to bring out in the care of these patients, is that in these fractures of the lower and middle third, it might be well not to run the cast up quite to the axilla, because very often the lower fragment will be anteriorly displaced, and if in attempting to displace it posteriorly the cast runs too high, we merely push the upper fragment back instead of controlling the lower fragment.

In some of those fractures, if you want to get a very good reduction at the time with the fracture in complete alignment, run the cast only to the fracture line, so that in tightening the sling you can tilt it backward to control it.

The only thing original, possibly, that we have done is the addition of the pad up here in the barrel-chested man or in the woman with large breasts, in which the arm hangs over the fracture and gives you an external angulation. We put the wedge down here. Occasionally, with the opposite displacement, it is well to put the pad up and let the arm hang over the pad.

I should say that we have been greatly pleased, as we have shown, with the results. Since November 23, 1935, to February 21, 1941, in the Bone and Joint Department alone, some of which cases are included here, we have had 252 cases which we have followed, and among those have had no nonunions.

R. ARNOLD GRISWOLD (Louisville, Ky.): As Dr. Winfield said, this is a method which, when you consider it superficially, breaks some of the rules of fracture treatment. It does not fix the joint proximal to the fracture, but it works, and comparison with traction suspension treatment of the lower extremity shows why it works. We have now used this method in a series of

almost 500 fractures of the humerus, of which we have follow-up figures on 425.

Fractures above the pectoralis must be reduced. The cast will not reduce fractures of the surgical neck and head. We use Gordon Morrison and Cotton's maneuver for the reduction, and hold the fracture with the hanging cast.

In the shaft, most fractures do not need reduction. However, there will be a percentage that will need manipulation and a small percentage in which soft tissue is interposed and in which operation must be carried out to remove the soft tissue from between the fragments. These may then be treated in the hanging cast with or without internal fixation at the site of fracture.

In fractures low in the shaft and the supracondylar region, we are likely to get deformity. When we break the shaft of the humerus, we loose the supinating effect of the biceps. The elbow joint comes under the control of the pronators which are by far the strongest muscles. When we attempt to supinate the elbow joint or put it in midpronation, it supinates not at the elbow but at the fracture site, and we get a varus deformity.

The varus deformity in lower shaft fractures is the result of supination at the fracture site instead of at the elbow, because the elbow is to all intents and purposes fixed in pronation; so that if the fracture is low in the shaft, the forearm should be put in full pronation in order to avoid this varus deformity.

With full pronation I do not think we need the wedge to get rid of this varus deformity. However, the wedge is a very handy thing in the barrell-chested individual or the woman with large breasts in whom the humerus cannot naturally hang in a vertical position.

We use this cast in almost all cases of fractures of the humerus, except extension fractures in children. We use it in extension fractures in adults and in T and Y fractures in adults if the displacement is not great.

So far we have used it above the insertion of the pectoralis in 191 cases. Of that series we had good x-ray and functional results in 113, fair in fifty-six, and poor in four. Of these four, three had stiff shoulders and one had a rupture of the long head of the biceps which was sutured and resulted in poor function.

In the shaft we have treated a total of 180 fractures. We had good x-ray and function in ninety-one, fair x-ray and function in forty-seven, and poor in eight. Of these eight, three had joint disabilities, two had osteomylitis following compound fractures, and there were three nonunions in the 180 fractures of the shaft.

For fractures involving the elbow, there were fifty-four in all, with good x-ray and function, twenty-three, fair, seventeen, and poor four. Those four cases of poor function were traffic elbow fractures which resulted in more or less complete ankylosis.

We believe that the use of this method has simplified to a great extent what used to be a very difficult fracture. Those of you who have old surgical textbooks published prior to 1900 have seen the picture of a man with a sling at his wrist, a co-aptation splint on his arm, and a bag of sand on his elbow. This is the same method of treatment and it still works.

JOHN PAUL NORTH (Philadelphia, Pa.): We have had our interest particularly directed during the use of this method to the question of union, because the shaft of the humerus is one of the familiar sites for delays in union, and because the lack of complete immobilization of a fracture is so commonly cited as one of the causes of delay in union.

Our routine use of the method has been limited to fractures below the surgical neck and above the supracondylar level, using other methods for the fractures at the ends of the bone. We have a small series of thirty-one fractures of the shaft. That is the portion of the bone where one might expect delay in union. Of the thirty-one, eighteen have shown firm clinical union before the end of six weeks. The remainder have been solid within eight weeks, with two exceptions.

One of these exceptions was a virtually bed-fast woman of seventy-eight, with a fracture in the lower third of her humeral shaft, who still at the end of thirteen weeks has only fibrous union. The other, a man of eighty-six with a fracture of the middle third, was an obvious candidate for open reduction because he had muscle interposed between the fragments, but his age and enfeebled condition contraindicated any operation. He died at the end of twelve weeks with his fracture ununited.

Dr. Winfield has mentioned the fact that this method is not applicable to patients in bed. That is true in a sense, because the traction principle does not operate. However, the elderly patients who have to be confined to bed for one reason or another present a serious problem in finding any method of treatment which is applicable, and we have used the method in a group of eight patients who have been in bed for a large part of their early convalescence. The anatomical results have not been as satisfactory as in the patients who are ambulatory. The functional results have been good in the great majority of cases. The two patients I mentioned who had delay in union were in this bed-recumbent group of patients.

One patient was a maniac in the psychopathic division who defied all treatment. She was wildly active. We put on a hanging cast because we did not know any other way of treating her. She tore off the first cast. We put on a second and she chewed that off, and finally we got one on which stayed. I have a film of her arm at the end of four weeks.

This illustration shows the amount of callus which she has put out. I show her not as a good anatomical result, but I do not think such could have been secured by any method. This was in point of fact a swinging cast rather than a hanging cast, because most of the time she had her hand above her head, waving it in the air. It shows that incomplete immobilization in

this ease eertainly did not interfere with union but produeed exeess callus with a solid fracture at the end of four weeks.

I would sound a warning about the use of too heavy a east. We had a young girl on whom a rather heavy east was applied, and although it did not bring about eorreetion of the shortening at the fraeture site, it did produee a temporary subluxation of the shoulder joint.

ISIDORE COHN (New Orleans, La.): They say that a differenee of opinion is the reason we still have horse raeing in Kentueky.

I first saw Dr. North present this method in Philadelphia a few years ago. I was struek by the good results whieh he showed, but to my way of thinking, it still violated some of the fundamental prineiples that I have understood with regard to fraetures. In the first plaee, Dr. Winfield said this is a form of balaneed traction. The only thing that I ean see that it balanees is the shortening effect of the bieeps and trieeps, but it does not have any effect on the pectoralis major or the external rotators.

We have talked about immobilizing fractures in other plaees; why not have fixation of fraetures of the humerus? You certainly have no fixation here. We saw some pictures up there with a lot of callus around. Why that does not involve some of the nerves in the arm is beyond me, that's all. Without balanced traction, without fixation at the site of the fraetures, a lot of the things we have said and taught about fractures have just got to go by the board.

Another thing, it is perfeetly evident to me that this method does permit unopposed rotation of the shaft and can result in an axial rotation of the limb.

I believe in the abduetion type of dressing, whieh we have been using now for elose to thirty years, with fixation of the elbow and the shoulder, and suffieient external rotation to overcome the internal rotation of the peetoralis major is of importanee. And while I cannot present 500 cases in one instanee and 250 in another, smaller series earefully observed by individuals are of as mueh importance as large series presented, even though one is overwhelmed by statistieal eompilations.

Personally, I believe that the old prineiple of fixation of the site of the fracture, taking into eonsideration all of the anatomieal prineiples, is of importance; and certainly if one is going to use traetion, it ought to be balanced traetion, that is, traction taking into consideration all of the elements which may have to do with the fraeture.

ROBERT H. KENNEDY (New York City): I wonder if I may ask a question of Dr. Winfield, Dr. Cohn and Dr. North. I would like to ask whether they are teaching this method to medical students at the present time as the method of ehoice in these fraetures.

DONALD GORDON (New York City): I have never used this method. I have been very antagonistie toward it, but I am profoundly impressed

with the results shown here, both in numbers and in the results from its use in different parts of the country.

I had the opportunity of discussing this method in Philadelphia two
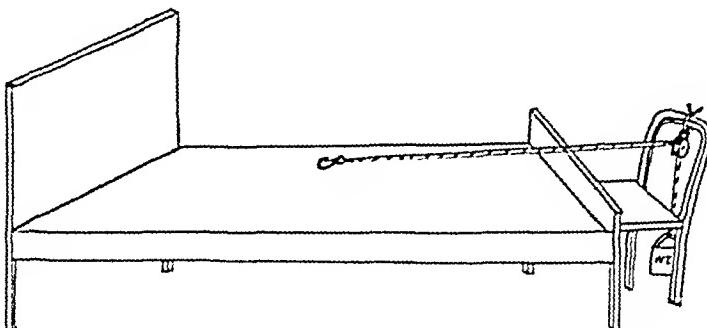
Fig. 11. Arrangement for traction at night for hanging cast.

years ago. At that time Dr. Hubley-Owen submitted a paper and admitted two violations of surgical principles. If we are told, as Dr. Cohn has brought out, to adhere to surgical principles, it seems to me that we should not depart from them. Although I have had no experience in this particular method, I have always treated my fractures of the humerus, that is, ambulatory cases, by a method which is a modification of the old Hamilton traction, namely, the narrow sling, the weight as suggested, and if needed, co-aptation splints.

I have found that in ambulatory traction of that type, as I interpret this hanging cast, it is an ambulatory traction, using gravity and the weight of the cast to afford traction, with a narrow sling or the equivalent of a narrow sling supporting the wrist. I have found that these patients, when they went to bed, in order to have the action of gravity maintained, needed a traction cord hooked to the traction spreader and carried through a pulley tied to a chair at the foot of the bed. The way I make use of gravity, I would suggest, can be made use of in the hanging casts.

Patients in bed or who are hospitalized, can be made more comfortable, I am sure, and the reason I seek comfort for the patient in a case of that sort, is that I do not want to be disturbed myself at night. The method I have adopted is to use traction at night as well as in the day time. The traction weight that I have used in the day time for the ambulatory patient, is proportionate to the musculature of the individual, and is buttoned to the traction straps attached to the arm. At night, that weight is unbuttoned and a spreader with a little ring on it is applied, a traction cord is hooked to this ring, the other end is passed through the pulley on the chair at the foot of the bed and is tied to a weight. I instruct the patient how to arrange that chair with the seat toward the bed, so that the weight will hang free. I tell them to snap the rope with a little snap into the wire ring. (Fig. 11.)

That, in conjunction with an axillary pad and swathe relatively immobilizes that arm, gives the patient comfort, and I obtain the objective which I am after not to be disturbed at night.

For patients who are not ambulatory and who are in bed, I would make this suggestion, to have a little wire loop attached to the elbow portion of the cast so that the night traction can be hooked into it. A number of cases may not require it, but in those that do, I think it will work.

LAURIE H. MCKIM (Montreal, Canada): I would like to say a good word for the hanging cast as applied to the fractures of the shaft, and I specifically make that statement.

Dr. Gordon has just covered one of the points I intended to bring forth. I will refer to that in just one moment. The hanging cast is really nothing more or less than a modification of the Jones' humerus extension splint which I am surprised to find so few men have learned to use. That splint, as you will remember, was the double bar with a ring around the shoulder, and parallel bars for the forearm in which the forearm was suspended. The degree of extension that was obtained was graduated by the point at which the sling for the wrist was attached to the bar.

The nearer it was attached toward the end of the fingers, the greater degree of extension was obtained. If too much was obtained, the sling was brought back nearer the elbow.

I have used this hanging cast for a number of years with the single modification that I have attached a number of rings to the cast, so that the amount of extension that I obtained could be graduated.

The other point I was going to bring forth, just brought out by Dr. Gordon, is that it can be applied to patients in bed, and I think it is a very distinct advantage to incorporate two small rings, one at the wrist and one at the elbow. Put a Balkan frame over the patient's bed, and when the patient goes to bed at night two hooks are attached with weights over pulleys, one to the elbow and one to the wrist.

During the night the arm hangs in this position in bed. It prevents swelling of the arm, you get rid of a great deal of edema that occurs during the day, and the following morning the patient can get up and attach the sling to the wrist and walk about during the day.

I wish particularly to refer again to the fact that graduated extension may be obtained and overextension, which sometimes occurs, may be prevented by attaching the wrist sling to the various points on the forearm.

CLAY RAY MURRAY (New York City): I would like to comment on this method of treatment, primarily from the basis of the series of cases presented here, and numerous other series which I have seen all over this country—evidently an example of a fracture getting well despite treatment.

The reason I emphasize this is because of the remarks which Dr. Cohn made. Dr. Cohn said as a result of seeing this series of cases, that all our principles of fracture treatment had to go by the board. That is the phase of the story on which I should like to comment.

I do not believe that is so. Because we have a series of cases which get well despite the violation of every principle known to fracture treatment is no reason why one should assume that, therefore, in all other fractures, we can do the same thing.

I think the principles of fracture treatment have to stand, despite the success of this method of treatment. There is no question about its success. I think the percentage of fair results is a good deal higher than is commonly found. I think Dr. Griswold's statistics brought that out in the "fair" results.

I think there is a language difficulty in the use of the word "fair," but his percentage of fair results was reasonably high, and fair results in fractures of the upper end of the humerus are unusual. Fair results should be a small number cases.

One might argue on the same basis if one were to say that this proves that the ordinary principles of fracture treatment should not be so rigidly observed, that necks of the femur should be treated in the same way that intertrochanteric fractures are treated. I think that would be a difficult thesis to uphold.

The fact that by apparently violating all principles of fracture treatment in the use of this method one can get good results in fractures of the shaft of the humerus, is no reason for trying a hanging cast or a pseudo-hanging cast to a tibia or a femur or both bones of the forearm. I think the apparent violation of principles, which is successful, should be distinctly limited to the humerus, and we should try to find the answer to the unquestioned riddle presented by the success of the method.

HENRY C. MARBLE (Boston, Mass.): I think this is developing into a little bit of a diehard of the ancients, who are dying hard on the violation of principles.

About 1924, or thereabouts, I presented at the American Medical Association a report of some cases in which we treated fractures of the surgical neck of the humerus by violating every principle of surgical treatment, and just letting them swing a flatiron. It hurt my surgical sensibilities terribly to do it, and the unfortunate part of it was that the patients got well with good results.

Apparently the upper half of the humerus is something which particularly admits of violation of surgical principles. My surgical sensibilities are shocked just as badly as Dr. Cohn's and Dr. Murray's. But maybe it is not all true; maybe it is not such a violent violation. Perhaps if we thought it over for a long while and got to the point where we do not put any cast or any splint on at all (if we must be medical purists, because this is not a cast), but put on a plaster splint and then reduced the plaster splint to nothing, and then perhaps if we just put a little piece of lead in the man's elbow, as in Scudder's first edition many years ago, we may get the very same results.

Maybe we are calling this the wrong thing. I do not think the application of the plaster splint does much to the patient. Maybe if you put a tiny weight at the elbow or on the bag, such as Dr. Griswold mentioned, we would get the same results. Surely the upper half of the humerus does do well, as Dr. Murray says, regardless of what we do to it, as long as we have motion.

This is not so bad a violation, because we do have motion. We keep the muscles in tone; we let the shoulder move. We violate another principle and let the wrist fall in the flexed position, but apparently they do perfectly well. Maybe in the future if we just take off the plaster entirely and put on a little lead foil over the elbow to do the same thing as this does, with still more violation, we will get just as good results.

The fact remains that here we have before us Dr. Griswold and Dr. Winfield and Dr. North. I have seen their cases, and they have perfect results. Why they do not all have radial paralysis, as so many of our patients do have, I do not understand. They have enough callus there because of motion; there is no radial paralysis; everything is wrong, yet the end result is good.

I never have used a hanging cast; I never could quite bring myself to it, but I have a feeling I shall now go home and swallow my surgical sensibilities and use the hanging cast because I think it is a swell thing.

CARLETON MATHEWSON, JR. (San Francisco, Calif.): I cannot understand why nothing has been said about distraction. In my experience, the most common site of nonunion and delayed union is in transverse fractures of the lower third of the humerus. We have attributed this to distraction.

In all of the cases of nonunion in the lower third of the humerus that I have reviewed, I have found that there was distraction present sometime during the period of treatment. Possibly the people in this part of the country are more muscular than our own and distraction does not occur. We have found in old, debilitated people that the weight of the forearm alone in the right position is enough to distract the fragments. If you maintain distraction during the period of treatment, nonunion will occur.

We have found it necessary in these cases, particularly in debilitated people, not to put traction on the arm but to attempt to force the fragments into approximation with one another.

PAUL B. MAGNUSON (Chicago, Ill.): I do not like to continue this when there is so much discussion that has preceded it, but I remember a number of years ago I came to Montreal and saw a pillow used for a splint by our President, Dr. Gurd, on fractures around the ankle, the lower end of both bones of the leg. I have found that that same pillow works very well as a splint for the humerus, especially in old people, if you put it on correctly.

Dr. Gurd called attention to the fact that a pillow should be pinned around by the pillow case and not the pillow. If you slip a pillow under the arm on these old people who are in bed, pin the top around the shoulder to

the one side, pin the pillow case around the arm and put the arm in a sling, these patients can get up or lie down. The pillow, if it is of the proper quality, that is, nice and soft and not too thin, will wad up and give just enough countertraction to make the arm perfectly comfortable.

It seems to me the muscles of the upper arm are entirely different in strength, in enervation and irritability than any other muscles that control the long bones.

Dr. Marble showed this perfectly, I think, in his treatment of swinging a flatiron for fractures around the shoulder many years ago, and I sat in the balcony the day he did it. I did not know him as well then; I could not call him a "nut," but that is what I thought.

But I went home and managed to put my surgical sensibilities where he says he is going to put his, and started to treat these fractures this way and got fine results. I came in the other day and found a patient of mine with a fractured humerus lying with the shoulder and the elbow on the bed, and complaining of pain. The answer was there was no support to take off the cross-strain. As soon as the pillow was put upright, with support from the shoulder to the elbow, the pain disappeared. The next day, as I had her lean over and begin exercising her shoulder with the pillow, holding the end of the fingers with the pillow, she was perfectly comfortable.

That has been my experience with fractures of the humerus. They do not need pull; all they need is support. If you can get these patients to relax their shoulders while they are upright, and let the arm hang, they do not have pain; there apparently is not any tendency to displacement; and if you will give them support between the shoulder and elbow with a mild support of the pillow traction between the axilla and the flexed elbow, they seem to do perfectly fine.

I quit worrying about them now since I have not put so much apparatus on to pull and push them.

FRASER B. GURD (Montreal, Canada): I would like to use one minute to point out that the humerus at the glenohumeral joint is the only joint in the body that is supported in the way in which it is, namely, with the long head of the biceps running through what is substantially a tunnel in the bone, and that the safety of a procedure such as described by Dr. Winfield and the other contributors this morning is dependent upon that cable-like support transmitted to the fracture line anywhere in the upper two-thirds of the humerus, or even down to the ultimate and penultimate fifths of the bone when the long head of the biceps is put under strain.

JAMES M. WINFIELD (closing): I would like to answer some of these questions, if I may.

I agree entirely with Dr. Gurd about the tendon of the long head of the biceps, helping to correct angulation and rotation. I can only say to Dr. Cohn that we do not believe the method of treatment violates surgical principles.

As far as Dr. North's experience with union is concerned, our results parallel his quite closely.

To Dr. Kennedy's question: Yes, we do teach this method to our students.

It seems to me that Dr. Gordon's method of treating the ambulatory patient is very much like ours. I agree with him about placing a hoop at the end of the cast, at the elbow, and we have utilized this in casts for individuals who have been confined to bed for a short period of time, although we do not believe that for prolonged bed treatment the hanging cast is particularly efficacious.

We did change the rings at the distal end of the cast, as Dr. McKim pointed out, not only distally and proximally, but also to increase and decrease rotation of the forearm.

Dr. Mathewson brought out distraction. I think it is a very important point.

I know Dr. Griswold has used light sugar tongs with some of these individuals instead of the cast. At times, the cast must be light, two or three pounds may be too heavy. This applies particularly to the transverse shaft fractures.

I think that is all I have to say, except that I should like to thank everyone for this very interesting discussion.

INJURIES TO THE ACROMIOCLAVICULAR JOINT*

A PLEA FOR CONSERVATIVE TREATMENT

Augustus Thorndike, Jr., m.d. and T. B. Quigley, m.d.

BOSTON, MASSACHUSETTS

OF the shoulder injuries occurring in individuals competing in body-contact sports, none are more common than those involving the acromioclavicular joint. Football, lacrosse, soccer, rugby and hockey are the sports in which such injuries are usually produced. The functional anatomy of this particular joint, the mechanism of injury, and a review of 173 cases are included in this study, together with a discussion of treatment. Admittedly, it is fortunate that a surgeon is present when these injuries occur; a diagnosis is made and prompt measures instituted for immediate treatment.

In view of a recent trend toward rigid fixation of injured acromioclavicular joints with pins and even screws, it seemed of interest to report the results of a large series of cases in which the patients were treated conservatively. Rigid fixation of this joint is not logical anatomically. Gray[1] states, "The movements of this articulation are of two kinds: (1) A gliding motion of the articular end of the clavicle on the acromion. (2) Rotation of the scapula forward and backward upon the clavicle, the extent of this rotation being limited by the two portions of the coraco-clavicular ligament. The acromioclavicular joint has important functions in the movements of the upper extremity. It has been well pointed out by Sir George Humphry that if there had been no joint between the clavicle and scapula the circular movement of the scapula on the ribs (as in throwing both shoulders backward or forward) would have been attended with a greater alteration in the direction of the shoulder than is consistent with the free use of the arm in such position, and it would have been impossible to give a blow straight forward with the full force of the arm; that is to say with the combined force of the scapula, arm, and forearm." According to Mollier,[2] the range of motion is approximately thirty in the coronal axis, fifteen in the vertical, and about twenty degrees

in the sagittal. Obviously, rigid internal fixation of this joint would seriously impair motion of the shoulder.

A review of the anatomy of this joint and the mechanism produc-
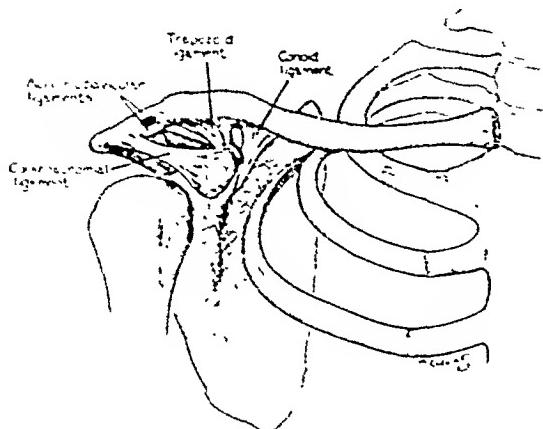
FIG. 1. Diagram of the ligamentous attachments between the clavicle and the scapula.
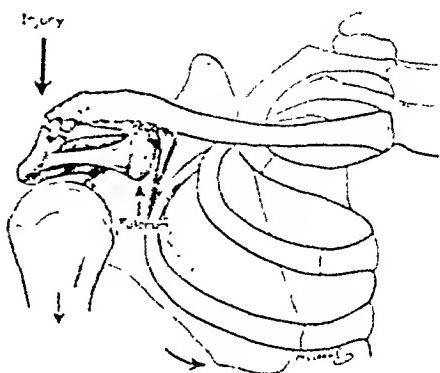
FIG. 2. Diagram showing the effect of a blow on the anterior or superior aspect of the shoulder beyond the end of the clavicle.

ing this injury seems appropriate. The joint consists of a rather weak capsule reinforced by five ligaments: the superior and inferior acromioclaviculars, the conoid and trapezoid coracoclaviculars, and the coracoacromial. (Fig. 1.) The articular surface of the clavicle lies on the acromion facing downward, outward and backward. This anatomic arrangement makes posterior or downward displacement of the clavicle almost impossible and such an injury is in fact a clinical rarity. However, upward dislocation of the clavicle, or perhaps more properly, downward displacement of the acromion, is common. The mechanism of this injury was first thoroughly studied by Porier and Rieffel[3] in 1891. These authors demonstrated that force applied to the anterosuperior aspect of the shoulder beyond the end of the clavicle causes the scapula to rotate so that the coracoid process becomes the fulcrum of a lever, the end of which is the acromion. (Fig. 2.) The superior and inferior acromioclavicular ligaments are the weakest points in the lever arm and give way easily, producing a partial dislocation of the joint. If the force is continued, the whole scapula is also depressed or rotated, the first rib becomes the fulcrum, and the much stronger conoid, trapezoid and coracoacromial ligaments may be injured, thus producing varying degrees of complete dislocation. (Fig. 3.) Partial separation is in our experience much more common than complete. As Cadenat[4] has

shown, the clavicle itself may well give way before the conoid, trapezoid and coracoacromial ligaments are affected.

Force applied from below, for example, from a fall or blow on the
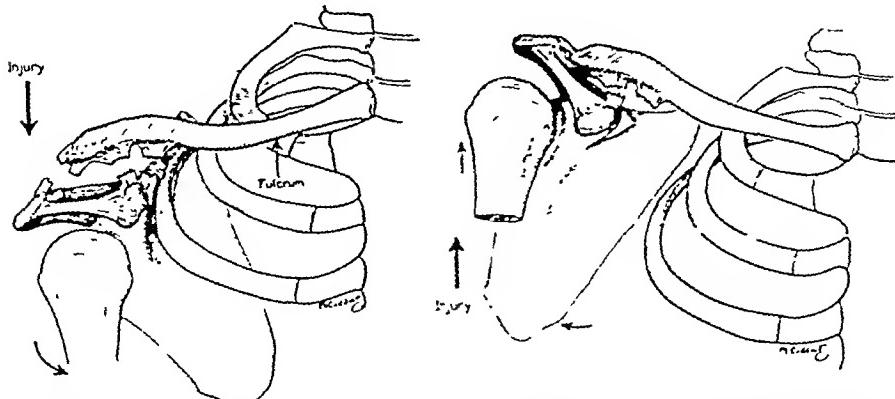
FIG. 3. Diagram showing the effect of a severe blow on the anterior or superior aspect of the shoulder lateral to the acromioclavicular joint.

FIG. 4. Diagram showing the effect of a blow transmitted from below through the humerus.

elbow and transmitted through the humerus, is a less common cause of injury to the acromioclavicular joint, but one that we have occasionally encountered. In this case, the scapula rotates on the acromioclavicular joint itself. The joint suffers more contusion than dislocation, and occasionally the conoid and trapezoid ligaments may be severely damaged. The medial end of the clavicle is held down by the strong costoclavicular ligaments. (Fig. 4.)

As a rule, there is little difficulty in establishing the diagnosis. Immediately after the injury the patient complains of pain about the whole shoulder, not necessarily localized at the acromioclavicular joint, loss of function and weakness of the arm. The acromioclavicular joint, and more particularly the clavicle and its articulation, supports the entire shoulder girdle. Occasionally, there is numbness, tingling or even transitory paralysis of the arm, the probable result of compression of the brachial plexus between the clavicle and the first rib. This symptom was present in four or 2.3 per cent of our 173 cases, in none of which could any subjective or objective evidence of nerve damage be demonstrated after a brief transitory period.

Examination reveals a considerable loss of function, of flexion, extension, abduction and adduction, together with tenderness directly over the joint, but often extending out over the deltoid and trapezius muscles. In cases in which the trauma has produced separation, increased mobility of the clavicle on the acromion can invari-

ably be demonstrated. Downward pressure or percussion on the medial third of the clavicle almost always elicits pain at the lateral end. The degree of separation is usually slight, but occasionally will produce complete dislocation, causing the clavicle itself to rest on the superior surface of the acromion.

The x-ray is of value principally in ruling out associated fracture. X-ray films were taken seventy-two times in our series of 173 cases, but minor displacement at the joint was demonstrated only eight times. Diagnosis of these displacements by x-ray films is not accurate and the x-ray should be resorted to only to prove the possibility of accompanying fractures at the margins of the joint. We have found in this series no marginal fractures of the clavicle, but one of the acromion. King and Holmes[5] have recommended an x-ray technic for proving the separation, but even this is fallible in the hands of most technicians. (Table 1.)

TABLE 1
ACROMIOCLAVICULAR INJURIES ALL SPORTS

Academic Year	Contusions	Sprains	Separations	Total
1934 to 1935	7	0	23	30
1935 to 1936	3	0	33	36
1936 to 1937.	7	1	23	31
1937 to 1938.	1	2	22*†	25
1938 to 1939.	3	3	15	21
1939 to 1940	3	5	22	30
Total.	24	11	138	173

* One case complicated by a fracture of acromion.
† One case of complete dislocation.

A variety of plans of treatment have been proposed. A number of operations have been devised, which fall into two general types: variations of the reefing operation, first described by Cadenat,[4] which lashes the clavicle to the acromion by fascial, silk or wire sutures, and operations designed to fix the joint with screws, wires or pegs. In none of our cases was operation necessary, although three presented marked displacement. For the rare case in which conservative treatment fails, we agree with Liberson[6] that careful reinforcement of the conoid and trapezoid ligaments is preferable to fixation of the joint. In this series we report operation was never resorted to.

The late Willis Campbell,[7] with whom we disagree, was of the opinion that "no form of conservative treatment is of any value,"

and advocates abduction in plaster of Paris for six weeks and opera-
tion for those with marked displacement. Codman,[8] on the other
hand, states that he has "never found it necessary to operate on
acromioclavicular dislocation."

FIG. 5. Adhesive tape fixation of separa-
tion of the acromioclavicular joint.

FIG. 6. Protective taping used after in-
jury to the acromioclavicular joint.

The many conservative strappings which have been described by
Eliason,[9] Howard,[10] Wilson and Cochrane,[11] and others, are in
general modifications or refinements of the brachioclavicular sling
of Sir Robert Jones,[12] the principle of which is elevation of the
humerus and depression of the clavicle. In our experience, elevation
of the humerus is unnecessary and adequate fixation can be obtained
by simple adhesive strapping across the joint from the lower angle
of the scapula posteriorly and carried over the joint and down on to
the anterior thorax. (Fig. 5.) A small felt pad is fixed across the joint
by the tape. This method of external fixation we recommend for
immediate treatment, and in the more severe cases we occasionally
use a triangular sling for a few days.

During the years 1934 to 1940, strapping of this type was applied
to 138 separations of the acromioclavicular joint occurring in college
men participating in athletics. In every case, treatment was insti-
tuted immediately after the injury. For the first few days treatment
was directed as much to the associated contusion as to the disloca-
tion, but the joint was immediately fixed with adhesive tape as soon
as the diagnosis was confirmed by the demonstration of increased

mobility. The strapping should be removed after forty-eight hours, high frequency diathermy applied for twenty minutes, followed by gently stroking massage and the strapping reapplied. This is repeated every second day for a total of eight days from the injury or until the shoulder function is tested for abduction, flexion, extension and horizontal abduction and, compared with the normal shoulder, reveals the return to normal. Not until normal function returns do we permit return to contact sport and only then with the protection of supportive adhesive strapping (Fig. 6) and special pads. The average period of disability for this series of separations was 10.5 days for all these types of injuries. The left acromioclavicular joint was involved eighty-one times, and the right fifty-seven times. As might be expected, football produced the greatest number of injuries, 106; rugby thirteen; hockey eleven; lacrosse six, and track two. In two cases, in addition to the usual treatment, the joint was infiltrated with novocain without benefit. (Table ii.)

TABLE II
PERIOD OF DISABILITY
Injuries to the Acromioclavicular Joint

Contusions		Sprains		Separations	
No. of Cases	Days	No. of Cases	Days	No. of Cases	Days
24	9.2	11	6.1	138	10.5

Average disability for the 173 cases was 8.9 days.

The one case in the series which we did not have an opportunity to treat immediately after the injury is of sufficient interest to merit a detailed report:

CASE REPORT

W. B. consulted one of us (A. T., Jr.) sixteen days after sustaining an injury to the right shoulder in a semiprofessional football game. An x-ray had been taken elsewhere and cold applications had been prescribed. After a week of marked discomfort, an osteopath was consulted who strapped the shoulder. Pain and discomfort continued despite the strapping which was removed by the patient after another week.

Upon examination there was found a typical severe dislocation of the right acromioclavicular joint. The clavicle lay on the top of the acromion.

The dislocation was easily reduced without an anesthetic and held with strapping across the joint. (Fig. 6.) Immediately after the strapping was applied the patient stated that he was comfortable for the first time since

the occurrence of the injury, sixteen days before. X-rays taken before and after reduction and taping showed normal realignment of the gross displacement of the bones. (Figs. 7 and 8.)

FIG. 7.   FIG. 8.   FIG. 9.

FIG. 7. Case W. B. Dislocation of the clavicle on the acromion for sixteen days.
FIG. 8. Case W. B. After reduction.
FIG. 9. Aseptic necrosis.

Three weeks later the strapping was removed and displacement did not recur. Three and one-half weeks later he resumed football as a blocking back, with protective strapping to the joint. He has played through two seasons since without trouble from the shoulder.

The sprains of the joint are minor degrees of the same type of injury and are treated in much the same way. Contusions involve not only the joint, but the marginal muscle attachments at the joint, the deltoid and the trapezius. The restoration of full function in these latter occasionally prolongs the disability period. Treatment involves reduction of the hematoma and hastening of its absorption by immediate cold applications and compression bandage and later heat and massage.

Complications. Among the complicating factors of injuries to the acromioclavicular joint are: (1) Marginal fractures involving the acromion or clavicle; (2) contusion with transient palsy of the brachial plexus; (3) an interesting type of bone lesion seen only in protracted cases and having the x-ray appearance of aseptic necrosis adjacent to the joint surfaces. Of these latter complications we have seen two. (Fig. 9.) At the margins of the joint there are punched out areas of rarifaction. Tenderness persists as a rule for at least three weeks and disappears as the x-ray appearance of the bone returns to normal. The lesion is obscure but of general interest.

SUMMARY

1. The functional anatomy and the mechanism of injury to the acromioclavicular joint is discussed.

2. A simple conservative method of treatment is described, together with the result of its application in 173 consecutive cases.

REFERENCES

1. GRAY, HENRY. Anatomy of the Human Body. 21st ed., p. 316. London, Warren H. Lewis.

2. MOLLIER, S. Veber die Statik und Meehanik des Menschlichen Sehulter gurtels unter normalen und pathologisehen Verhaltnisse. Festschrift zum Siebenzigsten Geburtstag von Carl von Kupffer. Vene 1922, Gustav Fiseher.

3. POIRIER, PAUL and RIEFFEL, HENRI. Mechanisme des luxations sus—aeromiales de la clavicule, leur treatment par la suture osseuse. Arch. gen. de med., 1: 396–422, 1891.

4. CADENAT, F. M. The treatment of dislocations and fraetures of the outer end of the clavicle. Internat. Clin., 27: 145–169, 1917.

5. KING, J. M., JR. and HOLMES, G. W. Review of 480 roentgen-ray examinations of the shoulder. Am. J. Roentgenol., 17: 214–218, 1927.

6. LIBERSON, F. The role of the coraeoelavicular ligaments in affeetions of the shoulder girdle. Am. J. Surg., 44: 145–157, 1939.

7. CAMPBELL, WILLIS. Practice of Surgery, Dean Lewis. Vol. II, chap. v, page 52.

8. CODMAN, E. A. The Shoulder. Page 307, Boston, 1934. Thomas Todd Co.

9. ELIASON, E. L. Nelson Loose-Leaf Surgery. Vol. III, pages 196–200.

10. HOWARD, N. J. Aeromioclavicular and sternoclavicular joint injuries. Am. J. Surg., 46: 284–291, 1939.

11. WILSON, P. D. and COCHRANE, W. A. Fractures and Dislocations. Pages 74 and 75. Philadelphia, 1925. J. B. Lippincott Co.

12. JONES, SIR ROBERT. Injuries to Joints. 2nd ed., page 56. London, 1922. Henry Frowde and Hodder and Stoughton.

DISCUSSION

JAMES M. WINFIELD (Detroit, Mich.): It is a pleasure to discuss Dr. Thorndike's excellent paper. In recent years there have been a considerable number of articles dealing with this subject. I might say that they can be divided into those preferring early operation, the nonoperative conservative group, then the group that tries conservatism and operation, if necessary, after conservatism has failed.

As we belong to the conservative group, as does Dr. Thorndike, I am afraid that my discussion may not be sufficiently critical. However, it is my impression that the acromioclavicular separations that we see are possibly a little more severe, in general, than the ones that Dr. Thorndike sees, the degree of forces being greater which have produced the injury in our cases.

In the last twenty-one cases that we have had of these injuries, three were very severe with marked displacement. One of these patients out of the twenty-one cases came to us three weeks late with marked separation and a very painful shoulder. We treated this individual conservatively for five weeks, and the pain in the shoulder persisted. We resorted to operation, and we did much the type of operation described by Dr. Speed.

I would like to show a dressing that we have used for the more severe types of injuries. (Fig. 10A.) Dr. Miller, our surgical resident, devised this. It was simply a modification of the Jones' brachioclavicular splint or

dressing, and very much like Howards'. We placed a posterior right angle plaster splint or a very light circular cast on the arm to hold the arm at right angles. Then with the sponge rubber pad over the clavicle, we make

FIG. 10. A, type of brachioclavicular dressing for acromioclavicular separations; anterior view. B, posterior view of brachioclavicular dressing.

pressure down on the clavicle, lifting the arm upward by the use of adhesive strapping or elastic bandage. Figure 10B is the posterior view.

I believe that for the severe injuries, a little more controlled immobilization is necessary than described by Dr. Thorndike.

The point about aseptic necrosis, I think, was a very interesting one. We have not observed this lesion in our injuries.

Again I would like to say that I have enjoyed Dr. Thorndike's paper.

ARTHUR R. METZ (Chicago, Ill.): Dr. Thorndike has given us a very nice description of the anatomy about the acromioclavicular joint, which makes the treatment appear very simple. In our experience dealing largely with railway men in whom the shoulder injuries sometimes are rather severe, it is impossible to hold the dislocation of the clavicle by strapping with adhesive.

Injuries of this type are x-rayed with the patient standing so that the dislocation shows its maximum displacement, which is usually one-half to three-quarters of an inch. Such displacements we have not been able to hold down by strapping or by a pressure bandage which runs over shoulder and around below the elbow.

In working men over twenty-five years of age we regard this a major injury which may be very disabling.

In manipulation of such an injury under the fluoroscope, it will be observed that the acromium approximates the outer end of the clavicle when the elbow is elevated to about the level of the ear. As a result of this observation we treat all recent injuries to the acromioclavicular joint, with actual separation, by putting the patient to bed for three weeks with his arm suspended so that the elbow is on a level with the ear. This treatment, as a rule, gives good results in six to twelve weeks.

Patients who have not been treated are occasionally seen in which the dislocation has persisted and the patients are able to continue at heavy manual labor.

Dr. Frasier Gurd, of Montreal, presented a case before the Fracture Committee in which the entire clavicle had been resected and the patient returned to regular manual work.

It would seem that with the excellent results reported by Dr. Thorndike and Dr. Quigley that we have the choice of three different methods of treatment of injuries to the acromioclavicular joint, depending upon the severity of injury and age of the patient: (1) Strapping the shoulder with adhesive in young athletic individuals, in which damage is not too great; (2) in more severe cases and older patients, rest in bed for three weeks with elbow elevated to level of the ear; and (3) resection of the outer portion of the clavicle or entire clavicle if the condition becomes disabling.

GORDON MURRAY (Toronto, Ontario): I believe I am one of the culprits to whom Dr. Thorndike referred when he said we preferred to use pins and spikes and screws, and other obnoxious things, in this joint.

First of all, I enjoyed his paper very much indeed. I think in the ordinary dislocation, function is returned fairly well. However, when the coracoclavicular ligaments are torn, it is a different matter; and it is a different matter also in women in whom deformity is of great importance.

In those people we have had best results by putting a wire through the joint, putting it through the deltoid, through the acromion and into the clavicle. In our cases with coracoclavicular dislocation and wide separation we have had excellent results. We were able to hold them quite satisfactorily with one or two pins, and in the ordinary dislocation of the acromioclavicular joint alone, the results have been excellent.

These people are able to continue at work, provided it is not laboring work, beginning on the second or third day. One patient with a coracoclavicular dislocation had it fixed up, came back in two weeks and said he was feeling well. We discovered shortly that he had returned to work as a laborer. I asked him what sort of weights he was lifting, and he said, well, he did not lift anything more than two hundred pounds. He has a perfectly satisfactory result.

I believe, at least in my hands, that to be certain of a good cosmetic as well as functional result, there is no disadvantage and there are some advantages in passing a pin through this joint. Usually the pin must be taken out at a later date.

MARTIN C. LINDEM (Salt Lake City, Utah): I would like to call attention to a complication encountered which has not been mentioned by Dr. Thorndike, and that is osteochondritis of the joint. The appearance, probably, in the x-ray was very similar to the case he showed with a cystic degeneration at the end of the clavicle, but in this joint where was a collection of half a dozen pieces of bone, which were covered all around with cartilage, very similar to or identical in gross appearance to an osteo-

chondritis of the knee-joint after separation of a foreign body. The joint also contained thin, serous fluid.

The joint was cleared of the foreign body, the cartilage surface was débrided as one would do in a knee joint. The covering of the joint was closed without any fixation of the bones, and there has been a completely good function.

FRASER B. GURD (Montreal, Canada): Dr. Metz has referred to the fact that last year in February before the Fracture Committee, I showed a couple of cases, and will show the same pictures now that I used at that time, apologizing to those Fellows who were present last year at that meeting.

The pictures of these three cases, in two of whom the lateral third of the clavicle was resected on account of acromioclavicular dislocation and, in the third, complete resection of the clavicle was performed seventeen years ago for sarcoma, proves that there is no deformity and no loss of function in consequence of this form of interference. This subject was presented before the Ann Arbor Meeting of the Central Surgical Association recently. The pictures will be published in its discussion.

My thesis in the matter is that the clavicle is one of the spare parts, as far as the human anatomy is concerned, and that any part of it or the whole of it may be removed without disability, and that in consequence, for the severe type of either marginal fracture or complete dislocation of the acromioclavicular joint, particularly if it is of long standing, a simple conservative method of treatment is the resection of the lateral third, or thereabout, of the clavicle.

DONALD GORDON (New York, N. Y.): Some years ago, when the infections of the operating room did not afford the same freedom in operating on bone cases as is the case today and these problems presented themselves to us in the out-patient department I had occasion to try the old Stimson method. I immediately found disadvantages in it, due to the fact of the pain caused by the pressure of the adhesive where it passed over and supported the upper part of the ulnar.

To meet that, I put a co-aptation splint, using a padded co-aptation splint for the forearm and hand to rest in. Figure 11A is the front view showing the adhesive fanned out so that it might have an adequate pull on the trapezius. You will note a little ring in the distal end of the splint near the hand. With the patient ambulatory, the weight of the forearm pressing down, as it will by the action of gravity, will pull on the muscles which tend to elevate the outer portion of the clavicle.

I also found that this was more successful in the type of dislocation in which there was an associated fracture of the outer end of the clavicle, as shown on the right hand side of the slide.

Figure 11B is the posterior view. To make this active at night when the patient was in bed, I utilized the same weight traction gadget as suggested in the hanging cast, attaching the cord to the ring in the distal end of the splint.

I appreciate very much the simplicity of Dr. Thorndike's method, and I think that it, in combination with the suggestion of Dr. Winfield, shown in his picture, appears to me that it might be called the "hanging adhesive," or the "hanging adhesive plaster cast."
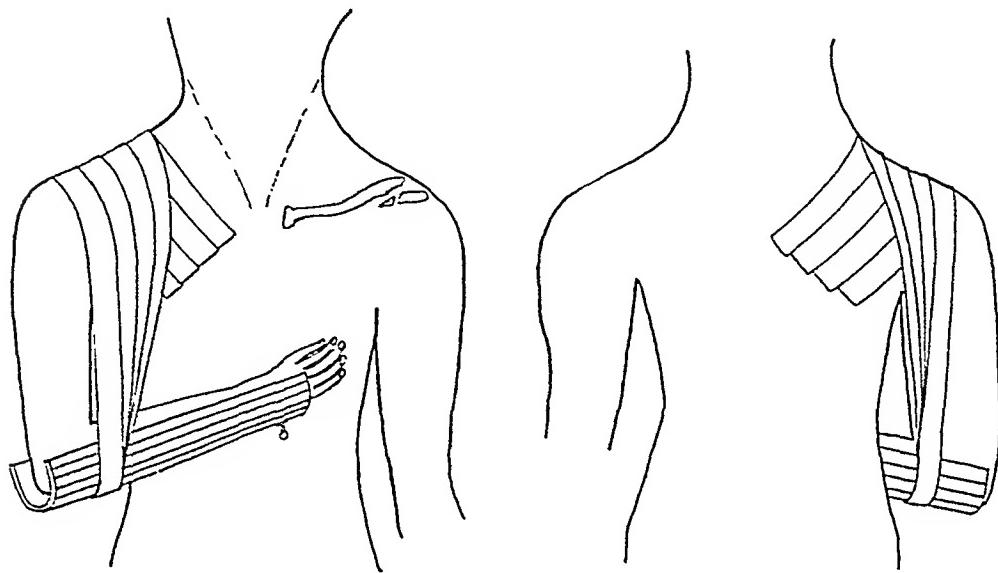

FIG. 11. Modification of Stimson dressing for acromioclavicular dislocation. A is the front view; B the back view.

AUGUSTUS THORNDIKE, JR. (closing): I want to thank the gentlemen who expressed their own principles quite frankly. I still, however, believe that we are fortunate in seeing these cases immediately, instead of an hour, six hours or longer afterward. If one can apply that fixation immediately, I am certain that one can hold that clavicle down on the acromion.

I do not know much about the railroad man and climbing, but I am sure that this boy here could have climbed up a box car perfectly well in the three weeks without having laid in bed. He has been ambulatory at all times and even prior to my seeing him, the dislocation having occurred fourteen days previously.

Concerning the deformity in women, I have had no experience with trying to satisfy the cosmetic results. I can see where that could be quite different. I believe that even if the wire or pin has to be removed, it is probably worthwhile for a short period.

In reference to osteochondritis, probably I used the wrong term in describing that rarefaction that appears at the end of the clavicle by calling it aseptic necrosis, but this patient was not operated upon, and the x-ray appearance changed to normal over the course of three months, so that the cystic appearance and the irregularities were all smoothed out.

I want to thank you gentlemen very much for being so forebearing about a very simple little type of treatment for such injuries as the acromioclavicular joint receives.

COMPLICATING FACTORS IN THE TREATMENT OF INJURIES TO THE MENISCI OF THE KNEE JOINT*

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THIS paper is not intended to deal with the diagnosis or treatment of meniscus injuries *per se.* In it will be discussed the various factors, exclusive of the meniscus injury itself, which we have found to influence the success of surgical treatment in respect to ultimate result and to disability time. It does not represent a purely statistical study, but rather attempts to analyze the experience of a hospital staff in dealing with these lesions over a period of thirteen years.

In evaluating this experience one must consider that 461 knee joints have been operated upon in this period, 79 per cent of which have had a history of trauma directly leading to the symptomatology and need for treatment, and of these 315 have had meniscus injuries proved at operation. These latter represent the patients operated upon out of a group of 631 cases in which the clinical diagnosis of meniscus lesion had been made, the remainder having been treated conservatively according to a rationale which will be outlined later in the discussion. Of the 631 cases 86 per cent were diagnosed as clinically certain lesions of the medial meniscus and 14 per cent were considered similarly as involving the lateral meniscus. Of the patients operated upon 85 per cent proved to be medial meniscus injuries and 15 per cent involved the lateral meniscus. In 10 per cent both menisci were involved. In addition to these 631 cases of clinically definite or operatively proved meniscus injuries, there were seen 623 cases of knee joint trauma diagnosed as sprain in the absence of definite clinical evidence of a specific lesion. One hundred one of these showed a hemorrhosis sufficient in amount to warrant therapeutic aspiration. All of these 623 cases were handled conserva-

tively, i.e., without operation, and are cited here merely to point out the fact that doubtful or vague diagnostic pictures were not considered in the group of cases forming the basis for the conclusions here voiced.

Another point of importance in the evaluation of this experience is the fact that the conclusions expressed are not a reflection of the writer's personal opinions, but represent the consensus on the service as a whole. Each case, while the patient was under treatment, has been openly and freely discussed by all members of the staff at our weekly staff conferences, and on every follow-up visit the findings as to anatomy, function, symptoms and economic rehabilitation have again been the subject of open and free discussion by the whole staff. Over 80 per cent of the cases have been thus followed for from two to five years after operation.

On the basis, then, of this experience, I will attempt to set down the factors which we believe are of importance in complicating the care of these patients.

The first factor for discussion is that of the rapid and profound hypotonia and atrophy of the rectus femoris, the vastus intermedius, and the vastus internus which ensues following intra-articular damage to the knee joint.   It is not an atrophy of disuse; it is well marked by the fifth day after injury in many cases, and always by the tenth day. While the atrophy has in some cases resulted in a two and one-half inch lessening in the circumference of the thigh 20 cm. above the tibial articular margin, the hypotonia is the most striking feature of the picture presented.   With this atrophy and hypotonia there is frequently loss of ability to contract the rectus voluntarily, and to less degree the internal vastus.   The nature of this curious phenomenon has never been accurately determined. Experimentally, it has been definitely shown that an identical phenomenon can be produced in the thigh extensors of the dog by removing a meniscus from the knee joint, and that its occurrence can be prevented if the knee joint is denervated before the operation is done. This experimental evidence is quite definite and quite striking. The vastus lateralis, in both clinical cases and in the experimental animal, seems relatively less affected by atrophy and hypotonia, and the power of voluntary contraction in this muscle is better maintained. When an operative procedure is performed on the joint it acts as an additional intra-articular trauma, and the atrophy, hypotonia, and loss of power of voluntary contraction are intensified. When a knee joint is subjected to repeated traumas over a period of months or years, as

by a recurring dislocating bucket handle cartilage, this atrophy and hypotonia become more or less "fixed," and even under excellent care many months may elapse postoperatively in such a case before extensor muscle power is regained.   Brantigan and Voshell[1] have published recently an excellent and clear-cut presentation of the integrated functions of the knee joint ligaments as demonstrated in cadaver experimental specimens. In the living subject, however, we believe that the function of these ligaments is a reserve function, utilized only when the stabilizing action of the normal musculature is caught "unawares" by a sudden and unexpected twist or lateral bend at the knee, or when the stabilizing power of the musculature is exceeded by the force of the trauma involved. We further believe that if the stabilizing power of the musculature on the knee joint is deficient, and the ligaments are therefore called upon to act as stabilizers per primam and to act continuously as such (instead of playing the part of reserve checkreins as occasion demands) low-grade inflammatory reaction—the so-called traumatic arthritis—will result with secondary changes in the synovia, in the fat pads, and in the articular cartilage covering the lower femur, the patella and the upper tibia. This question of clinical knee joint stability has been discussed by Darrach,[2] who rightfully stressed the point that complete ligamentous stability of the knee joint is clinically demonstrable only in complete extension and in complete flexion, the two positions which are very rarely assumed by the human knee joint in ordinary activities.

We, therefore, believe that next to the elimination of the pathological condition of the knee joint the most important factor in satisfactory results in meniscus injuries, both in regard to the ultimate outcome and to the rapidity with which full and unlimited function can be secured, is restoration of the lost muscle tone in the knee extensor apparatus and the elimination of the atrophy which affects the extensor muscles.

This belief affects our procedure in meniscus lesions in several ways. We do not believe in repeated attempts at conservative treatment in recurrent meniscus lesions. A certain percentage of primary meniscus lesions undoubtedly entail tearing of the attachment of the meniscus to the lateral ligament of the joint and the adjacent capsule, which, as Brantigan and Voshell[1] have shown, is of rather loose texture, or of tearing loose of the anterior or posterior attachments of the menisci. The rest are tears through the meniscus itself, bucket handles or flap tears. We know of no way in which these two types of

lesion can be distinguished one from the other clinically. We believe that the ligamentous tears will heal if the meniscus can be held in relation with its normal contacts by extension of the knee, and that the tears through the meniscus itself will not heal. The experimental work of King[3] on this point is quite convincing. Since we are unable to differentiate between the two lesions clinically, and since we know of no data as to the relative frequency of the two, we treat all first meniscus lesions conservatively, *if possible*. Only those which evidence locking of the joint, and in which the locking cannot be reduced under an anesthetic, are urged to undergo primary operation. The others, those which have not locked, and those in which reduction of the locking has been possible, are aspirated if the hemarthrosis is large, and are then placed in extension in a circular plaster from groin to ankle. This is applied over stockinette only, with thin felt strip padding about essential bony points. The patient from then on is urged to walk about as much as possible on the extremity, using crutch or cane support for only as few days as possible, and to practise quadriceps contraction exercises at as nearly hourly intervals as possible for the next four weeks or so. If at all possible, he is returned to his ordinary occupation during this time. At the end of this period the circular plaster is removed and the natural exercise of the extremity plus the quadriceps contraction exercises are continued until the hypotonia and atrophy are eliminated. Any physical therapy which is used, and we prefer if possible to use none, is used for the relief of soreness and stiff feeling only, and in order that the patient may more easily and comfortably give the part exercise and use; and he is advised in no uncertain terms on that score. Three hundred sixteen clinically certain meniscus injuries so treated recovered completely without operation and without recurrence during the follow-up period. We are certain that in many of these cases, had immobilization been practised without the stress on use and exercise as the essential feature of treatment, relative instability of the knee would have resulted with secondary joint lesions leading to prolonged disability, and in some cases, the need for late operative procedures for the relief of these secondary lesions.

If, following conservative treatment such as described above, a recurrence of symptoms occurs, or if primarily the locked knee cannot be made to extend, operative treatment is initiated. In the two-day period which we reserve for preoperative preparation in these cases the patient is instructed in quadriceps exercises if he is a primary operative case or if he is a recurrent case not previously

treated by us. This is of course not necessary in the recurrent cases whose initial care was in our hands. Postoperative patients have a moderate pressure dressing applied for twenty-four to forty-eight hours, but start their quadriceps contraction exercises at the end of twenty-four hours. When postoperative quadriceps contraction is difficult to initiate it is aided by the use of the Smart coil to give nonspastic rhythmical contraction. It is frequently of value to teach the patient to contract first his good quadriceps, then attempt the contraction of the involved one, and then both sides simultaneously to a rhythmic count of 1-2-3. The value of such rhythmic bilateral exercise in breaking through the bar to voluntary contraction of the muscle is considerable, and it can be taught easily to the patient in the preoperative period. Voluntary knee bending is started when the pressure bandage is removed. The patient is up in a chair on the fourth day on the average, sometimes as early as the second or third day, is walking with crutches on the fifth or sixth day, and leaves the hospital walking without support or in some cases with a cane on the average on the ninth day. Frequent short periods of walking exercise are urged during the hospital stay and the quadriceps exercises are kept up in the hospital and later in the out-patient department. There is no question in our minds but that the rapidity of functional and economic rehabilitation in these cases is in direct proportion to the degree to which the patient can be made to carry out the restoration of his quadriceps muscle tone through voluntary exercise and use. Keeping a patient on crutches, deluging him with physical therapy, and postoperative immobilization of the knee joint are all conducive to delay in functional and economic rehabilitation.

In the cases of repeated recurrent meniscus lesions with marked atrophy and hypotonia, even more intensive attention to this factor is essential to success. In order that walking and exercise may be carried out without crutch support and yet without symptoms of pain and swelling in the extreme cases, it is wise sometimes to provide the patient with a jointed knee cage which will not interfere with motion but which will provide lateral stability until his muscles can do so. But he must be made to understand that its only purpose is to make it possible for him to practise an increased amount of normal exercise and use of the leg.

The second complicating factor which enters this discussion is the question of the incision used in the operative removal of menisci. It is, of course, not only possible, but usually quite easy, to remove a meniscus through any one of the small incisions frequently used on

either side of the joint; and if there is any difficulty in getting at the posterior attachment, an accessory incision in front of the biceps or the semi-membranosus will take care of it. But we have come to believe in the last thirteen years that the procedure is unwise. This belief is based on our proved inability to make the diagnosis of a meniscus lesion as the sole pathological condition present. In cases so diagnosed only 30 per cent of the knee joints have shown the meniscus to be the sole lesion. Seventy per cent of the cases have shown at least two lesions and over half of this 70 per cent have shown anywhere from three to eleven lesions in the joint. Darrach[2] reported on a six-year section of these cases in 1935 with very similar figures. Hypertrophied and fringed alar fat pads showing definite evidence of injury; softening, fraying, erosion and partial detachment of the articular cartilage on the femoral condyles, the posterior aspect of the patella, and the tibial articular surface; loose fragments of articular cartilage, often small, within the joint; hypertrophic spurs; unsuspected crucial ligament injuries presenting projecting stumps within the joint; unsuspected bilateral meniscus injuries; unsuspected synovial changes—these are some of the unexpected pathological lesions found. The high percentage of bilateral cartilage injuries—10 per cent—is possibly explainable on the basis of their being discovered by reason of more adequate exposure of the joint. In our earlier years, when we used the small incision, many of these were missed, and, as a result of continued pathological conditions in the joint, muscle hypotonia and atrophy persisted even after removal of the meniscus. We now use a long internal or external parapatellar incision, running from the top of the quadriceps pouch to below the tibial margin, which gives complete exposure of the joint when the patella is retracted to one side and the joint flexed. Wounds heal from side-to-side—not from end-to-end—and the length of the incision has not caused any increase in our convalescence time. On the contrary, with the removal of all pathological conditions present in the joint and concentration on the restoration of muscle activity postoperatively, unhampered by the deterrent effect of residual joint pathology, our convalescence time and functional and economic rehabilitation time have decreased, even as compared with the published findings of Darrach[2] in 1935. We, therefore, believe that adequate exploration of the joint is indicated in operations for the removal of a meniscus, and the concensus on our service is that we cannot get exposure for adequate exploration through the small incisions frequently used. The methods of dealing with the individual conditions have been

outlined by Darrach[2,4] in previous publications. Many of the degenerative changes in the articular cartilaginous surfaces and many of the synovial changes may be due, we believe, to the instability of the joint in cases of any standing, secondary to the loss of tone in the quadriceps extensor mechanism as much as, if not more than, to the direct effect of the presence of a loose and torn cartilage. We have not as yet found it necessary to do an anterior crucial ligament repair in order to restore stability to a knee joint, although in 8 per cent of our cases the anterior crucial was found completely torn, and in 6 per cent partially torn. Projecting stumps of anterior crucial ligament attachments have been removed. Our percentage of posterior crucial ligament injuries has been small—only a little over 1 per cent—but in only one case has the knee joint been unstable for a considerable time after operation although none of them were repaired. This case was one of long standing injury, with "fixed" atrophy and hypotonia whose co-operation in restoring muscle tone and regaining muscle power was minimal. It took two years to regain functional stability in his joint. It is possible that in this case time might have been saved in restoration of stability if a posterior crucial replacement operation had been done; but in general we believe that crucial ligament instabilities are best handled by intensively striving for the regaining of muscle tone and volume, and that operative repair should be reserved for those cases in which this proves impossible.

The third factor warranting discussion is the use of the tourniquet. There can be no question but that with its use operating time is cut down materially, and this is a definite advantage provided that time is not saved at the expense of the patient's subsequent welfare. With our conviction that adequate exploration of the whole joint is indicated in all operations based on a diagnosis of a meniscus lesion, the use of a tourniquet enforces anoxemia of the extremity below it for anywhere from forty-five to seventy-five minutes or more, using the Lane technic. In an extremity already compromised by loss of muscle tone and strength, we have been unable to believe that this enforced anoxemia was a matter of no import. We think, on the basis of our results, that we are justified in the use of the Lane technic and in the exploration of the whole joint. On the other hand, operating on a knee joint through a large incision under ordinary conditions without a tourniquet is apt to be a very bloody and messy procedure with visibility definitely clouded. We have finally worked out a technic which allows of the operation with very little bleeding indeed,

and that relatively easily controlled, and does away with the use of the tourniquet. The table, while the patient is prepared and draped, is placed in high Trendelenburg position, with the knee joint line just distal to the line of break in the foot piece of the table. This effectually drains the venous circulation. When the skin incision is made, the bleeders are surprisingly few in comparison with the patient in a flat position, and are dealt with by mosquito clamp and cautery as encountered. The towels are then clipped to the wound and the incision through the capsule and in the interval between the rectus tendon and the vastus medialis or vastus lateralis similarly dealt with before the synovia is opened. With a then dry field the synovia is opened, the patella retracted and the foot piece of the table dropped, leaving the thigh in the Trendelenburg position with the knee flexed at right angles over the edge of the table. With the complete exposure of the joint gross bleeding points can be dealt with by mosquito clamp and cautery. Bleeding ceases to be a factor of any importance with the use of this method, and a remarkably dry joint can be ensured. When the surgery on the interior of the joint is accomplished, the knee is again extended and the patient is lowered from the Trendelenburg position to the flat position, and any additional bleeding points then apparent are dealt with.

In suturing the incision, after thorough lavage of the joint with saline, the synovia is left unsutured so that any ooze which may occur can possibly escape from the joint into the surrounding tissues. A moderate cotton pressure bandage or Ace elastic bandage over dressings is then applied. We believe that since we have adopted this method we have fewer postoperative joint fluid collections, that we have less difficulty in getting our muscle rehabilitation started, and that we have fewer knee joint reactions postoperatively. By this latter term I refer to the occasional patient who runs a temperature with a relatively normal white and polymorphonuclear count but a high sedimentation rate, and acute pain and knee joint effusion for some days postoperatively. Before we embarked on the present technic this reaction occurred in 4.6 per cent of our cases. Cultures of both the wound and of fluid aspirated from the joint were negative in all these cases, and wound healing was normal. We believe that the prolonged use of the tourniquet and postoperative bleeding into the joint and capsular structures may have been responsible. Certainly there has been a marked decline in these cases since the adoption of the present routine, and we have not seen one for some time.

In this series of 315 cases there have been three infections. Two of these were in knee joints subjected to diagnostic air injection preceding operation seven or eight years ago. The third case was a streptococcic infection occurring during an epidemic of five clean wound infections on the service recently. There was no demonstrable source for this infection. All three patients recovered, but with marked limitation of function in two and bony ankylosis in the third.

In conclusion I might state a personal conviction that in general the supposed results of excision of the menisci of the knee joint, insofar as complete restoration of muscle tone and muscle power with complete functional stability of the knee, both in respect to the ultimate result and the time required to obtain it, are somewhat like the results supposed to be generally obtained in Colles' fractures. They are popularly dismissed with the bland assertion that the results are good. Adequate follow-up studies on Colles' fractures have shown that this assumption is not true in a reasonably large percentage of cases. From the experiences of our own clinic, and from what I have seen elsewhere throughout the country I believe the same holds true for meniscus lesions. I have attempted, in citing our experiences, to call attention to some of the factors which we believe to have been involved in influencing the ultimate result and the rehabilitation time in these cases as handled by us.

REFERENCES

1. BRANTIGAN, O. C. and VOSHELL, A. F. Mechanics of ligaments and menisci of knee joint. *J. Bone & Joint Surg.*, 23: 44–66, 1941.
2. DARRACH, WILLIAM. Internal derangements of the knee. *Ann. Surg.*, vol. 129, July, 1935.
3. KING, D. Regeneration of semilunar cartilage. *Surg., Gynec. & Obst.*, 62: 167–170, 1936.
4. DARRACH, WILLIAM. Chondritis of knee. *Ann. Surg.*, 110: 948, 1939.

DISCUSSION

MELVIN S. HENDERSON (Rochester, Minn.): Dr. Murray's paper is interesting and stimulating. He mentions many controversial points we might take up, such as the use of the tourniquet and the length of time required for the operation he describes, but discussions of that character cannot well be carried on here.

My contribution to the discussion of this paper is an attempt to show that it is high time we took an interest in our end results in knee joint surgery involving the menisci. The statistics in my first lantern slide, made in 1934, show that in a total of 343 operations wherein the menisci were

removed, fracture or distinct damage of the meniscus was evident in 221 cases; but in 122, no fracture was demonstrable, although occasionally we did make the note that the cartilage was thin, frayed or loose. Recently I have reviewed our statistics and we can now add to the 343 cases, 173 more making a total of 516 cases in which the cartilage was removed. However, even in the light of the increased experience, I find that positive pathological conditions found are no higher in the larger group than they were in the previous group reported in 1934.

Basing the statistics on the 1934 group, we found complete relief in 77 per cent, improvement in 14.4 per cent; and no relief in the balance. In reviewing the records of sixty-nine patients, concerning whom a note had been made at the time of surgery that we could find nothing wrong with the cartilage and that the pathological condition found was insufficient to account for the symptoms, only 27 per cent obtained relief. Perhaps if we had closed those knees without removing the cartilage, the result would have been nearly as good.

It is interesting to note that Dr. Murray believes damage to the anterior crucial ligament is of very minor importance. It is my belief that many of the unsatisfactory results following removal of the meniscus are due to the fact that the anterior crucial ligament was torn or stretched at the time of the injury and that the symptoms which persisted were those resulting from injury of that ligament. Such papers as Dr. Murray's are needed; it is evident that his experience must have been similar to ours, namely, that there are too many indifferent results in this type of surgery and that he is deliberately making his operation more painstaking to see if the results cannot be improved. I shall enjoy reading the complete paper when it is published. .

PAUL B. MAGNUSON (Chicago, Ill.): I am tremendously disappointed in Dr. Murray, because I find myself for the first time almost in history, agreeing with him on almost everything he says. Consequently, I find it difficult to discuss his paper satisfactorily myself.

I have done considerable experimental work on knees, and have found myself in diagnosis very deficient, as apparently Dr. Henderson admits to being, which is consoling. There is nothing, I think, in the line of bone and joint diagnosis that is much more difficult than telling why a knee slips, clicks or locks or gives way of which the patient often complains.

Now, there is no doubt but what the mechanics of the knee are responsible in a fairly large number of cases; there is a bearing surface which must work on two curves, which must synchronize in all motions of the knee, and once there is a little divergence in the rotating arc of the tibia around the condyles of the femur, there is irritation.

Irritation in a joint, if often repeated, sets up some form of arthritis in the joint. A true picture of hypertrophic arthritis can be produced in dogs by cutting the internal lateral and crucial ligaments and allowing the dog free

exercise. It will not be produced if that dog is put in the ordinary laboratory cage. He has to be taken out where he can have free exercise.

Then, almost universally, those animals will develop a true picture of hypertrophic arthritis with spurs, and after they appear the erosion of the cartilage starts. That can be traced in definite proportion to the amount of exercise the dog has had and the length of time he has had that exercise.

Often repeated, small trauma has a definite effect on the production of erosion of the cartilage.

There are two kinds of degeneration of cartilage: One starts at the matrix, the other at the surface. The degeneration that starts at the matrix is wider at the base, and comes to a cone-shaped end at the surface. It shows degeneration starting below.

I do not believe we see that type of degeneration in purely traumatic arthritis. In my experience, the traumatic cases have degeneration of the cartilage at the surface, progressing toward the matrix.

Dr. Murray called your attention to the fact that he shaves the dead cartilage off down to the place where he finds normal or glistening hyaline cartilage. In many of these cases, especially on the weight-bearing surfaces which have had irritation of the joint, we find roughening of the surface, a granular surface, a villous-looking surface of cartilage, not villi growing in from the synovia, but an appearance of the cartilage that almost looks like coarse velvet. When this is cut or shaved off parallel with the matrix, we find that depending on the length of the time that the degeneration has lasted and the severity of it, we get down to normal hyaline cartilage. That will develop from the matrix if it has an area on the matrix's left. If it has no healthy matrix underneath, it will continue that degeneration.

These cartilage cells on the surface will show condensation of nuclei, threading out of the cartilage and poor staining qualities, while down below, the nearer you get to the matrix the more normal and growing cartilaginous cells appear. Therefore, I think we can fairly assume that the more rough spots that we have in the joint, whether they are due to irritations caused by semi-lunar displacements or fractures, or to a wobbly joint, or to trauma at some distant period which has knocked up small pieces of cartilage, the greater the necessity for adequately dealing with this pathological tissue. A piece of cartilage which is knocked up away from the matrix will degenerate into fibrocartilage in three weeks in experimental animals, and then float around in the joint and act as a mechanical irritant. We find these things in weight-bearing joints as well as in the elbows of boxers and bowlers. The strange thing is that boxers have it more frequently on the end of the humerus, on the condyles, and the bowlers have it on the articular surface of the olecranon.

KELLOG SPEED (Chicago, Ill.): Just as we make mistakes in abdominal diagnoses, and abdomens are opened for certain things which are found not to be present, I find that a similar situation exists in the knee joint.

I would like to show three slides illustrating some of my experiences in the diagnosis of so-called cartilage fractures or injuries in which other things were found. The results may be dependent upon these unknown or unexplored or unbelieved complicating pathological conditions, consequently the clinical pathological condition may be worth while inquiring into.

In a series of three hundred cases, the joint was always found sterile. There was osteochondritis in eighty of them. Pre-existing pathological conditions may exist at the time of the diagnosis of cartilage injury, and these complications include the various things listed: habitual dislocation of the patella, loose bodies in the joint, old arthritis, tuberculosis of the knee, abscess, traumatic penetration of the knee, a double patella, ruptured tendons, and so on down the list, including osteo-arthritis, peri-articular gangliomas, traumatic neuritis, etc.

All those things must be considered, and they may have a bearing on the outcome and the result after an operation for cartilage removal.

THOMAS H. PETERSON (Boston, Mass.): I just want to put in a word for you who have not tried the posterior incision as described by Dr. Cave. I recently had an opportunity to compare, bed for bed, three different types of incisions on a number of cases, and I will say that from the standpoint of earlier and more rapid regaining of normal motion of the knee, I have found without any question in my mind, that the patients who had the posterior type of incision for the removal of the semilunar cartilage had a much more rapid return to normal motion than those who had other types of incision.

Dr. Cave, as you know, claims that it is much easier to remove the posterior portion of the cartilage that way, and I certainly agree with him, although I do not think that it is entirely necessary in every case. On the other hand, if you are going to explore the knee as you do in the straight or parapatella incisions, the posterior incision is not satisfactory.

But I do believe that the posterior type of incision gives a much more rapid return of normal motion than that of any of the other types which I have had the opportunity to try.

REGENERATION IN THE ULNAR, MEDIAN AND RADIAL NERVES*

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THE problem of regeneration of injured nerves is dealt with extensively in the literature, but for the most part concerns itself with physiological experiments on laboratory animals. From a practical point of view, we are concerned less with the actual physiology of regeneration than with the ways and means of ensuring that normal physiological regeneration take place in a given instance and what may be expected as to prognosis under varying situations.

The problem of ensuring regeneration of nerves has been dealt with by numerous authors and is well understood, although modifications of treatment are still being originated. The question of prognosis has evoked many instances of personal opinion, but for the most part there has been a failure to substantiate these with clinical facts. In this report we shall summarize the experiences of the Massachusetts General Hospital for the past ten years with injured nerves to the upper extremities, and endeavor to formulate prognostic guides that may prove of assistance to others.

The study of regeneration of nerves has several inherent difficulties: The duration of time involved makes it almost impossible for one man to follow any considerable number of patients to an end result and certainly even in an institution such as the Massachusetts General Hospital, the varying expressions of opinion as to progress found on records become very perplexing. Then, too, the determination of the exact time at which regeneration may be said to have begun and at which it has reached an end stage requires arbitrary decisions and may involve considerable error. More difficult still is the definition of what exactly constitutes good and poor results.

In the past ten years at the Massachusetts General Hospital we have found records of 147 instances of injured nerves of the arm. Of these we have reasonably good evidence as to the eventual result in 110 or 75 per cent. The results were obtained in eighty-one patients

by personal observation in the hand or fracture follow-up clinics, in eleven instances by letter, which at least gives subjective impressions, and in eighteen instances from information supplied by various observers on their records.

Classification of results, as has been mentioned, is probably the greatest stumbling block for the reader of reports on follow-up of nerve injuries. As Pollock and Davis[1] point out in the collection of reports they have assembled from twenty-one authors, if criteria of success are mentioned, which frequently they are not, no two authors have fixed upon precisely the same yard stick by which to distinguish a good result from a poor one. It has seemed to us that the prime requisite by which to determine the success or failure of treatment to an injured nerve is the ultimate usefulness of the hand and arm to the patient. As it is obvious that what might serve a day laborer with complete satisfaction might prove entirely useless to a skilled craftsman or a musician, we have chosen to employ as a standard a hand that would prove useful for ordinary occupation and average everyday life. We have arbitrarily ruled that a hand with areas of anesthesia or hypesthesia to a marked degree cannot be considered useful not only because of the lack of sense of touch, but also because of the danger from burns and other injuries.

With the possible exception of the opponens pollicis, the intrinsic muscles of the hand supplied by the ulnar and median nerves are individually not of great importance; therefore, it is return of sensation that is essential as regards injuries to those two nerves, at least in the forearm. Regeneration of the sensory function of the radial nerve, on the contrary, is unnecessary for a hand to be considered useful, but the motor component must be present in order that a hand be so classified.

It may be said at the outset that in no instance in which physiological transection of the nerve occurred, have we observed 100 per cent regeneration, either in the sensory or motor components; although in a few patients improvement was still taking place years after a good result may have been said to have been attained, so that it is possible that we have not followed our cases over a long enough period of time. Accordingly, we have classified two cases as poor results that can be shown to have sensation throughout the nerve distribution area, but the hypesthesia is so marked as to interfere with the usefulness of the hand.

As may be seen from Table 1, we have classified 84.5 per cent of the nerves that we were able to follow for a sufficient period of time

as good results. This is a somewhat higher figure than is given in most reported series, which average about 65 per cent good results, but we have been fortunate in the follow-up of our patients and in being able to furnish them occupational and physiotherapy over long periods of time. In addition, most of the reported series are derived from injuries sustained in the last war in which conditions were unfavorable both to follow-up and to therapy.

TABLE I

RESULTS IN 147 INJURED NERVES OF THE ARM

	Total No. of Cases	End Result Determined in		Good		Poor
		No.	Per Cent	No.	Per Cent	No.
Sutured	88	65	73 8	51	78 4	14
Neurolysis	45	31	68 8	28	90 3	4
No operation	14	14	100	14	100	0
Total	147	110	74 8	93	84 5	18

We are not complacent about our results, for in too many instances the technical procedure employed was unfortunate and ill chosen and our results should be improved.

TABLE II

RESULTS IN FIFTY-FIVE INJURED ULNAR NERVES

	Total No. Cases	Results Determined in		Good		Poor
		No.	Per Cent	No.	Per Cent	No.
Sutured	32	21	65	19	90 4	2
Neurolysis	21	11	52 3	9	81 8	2
No operation	2	2	100	2	100	
Total	55	34	61 8	30	88 2	4

About one-third of the total number of injured nerves were ulnar. Unfortunately, we could determine the ultimate function in less than two-thirds of the cases although the results were considerably better than in either the median or radial nerves.

Most of the injuries occurred at the wrist so that innervation of the intrinsic muscles of the hand was lost. This, while it produces some deformity, notably abduction and hyperextension of the meta-

carpophalangeal joints of the fifth and to a lesser extent of the fourth finger and loss of the adductor of the thumb, results in surprisingly little incapacity. Regeneration of the motor component of the ulnar nerve almost invariably took place, although it apparently lagged behind the sensory nerve. In no case, however, have we observed the return of function of the adductor of the fifth finger.

The intrinsic muscles supplied by the ulnar nerve undergo extensive atrophy when the nerve is divided; and before function can be re-established not only must the nerve regenerate, but the muscle must develop enough tone and strength to perform its function. Therefore, it is not surprising that evidence of motor regeneration lags well behind sensory regeneration. As regards the adductor of the fifth finger, we believe that our lack of success is attributable to incorrect splinting in the past in that not enough attention was paid to keeping the fifth finger in adduction. Harmer[2] has achieved some brilliant results by the use of ingenious splints.

It is of interest that sepsis played no part in our poor results since in six instances all did well. It is doubtful whether age is of importance as a prognostic factor, for although the patients with good results averaged twenty-one years old and those with poor results thirty-one years, yet of the four over fifty years, all had good results.

The time interval between injury and operation is usually considered of paramount importance. Most surgical textbooks infer that immediate suture is more likely to be successful than a secondary suture. Of our patients, those sutured within six hours of injury showed eight good and one poor result, whereas of those sutured one month or more after injury eleven were successful and one was a failure. Four of the latter were over two years and one was four years following division.

It is obvious that in determining the rate of regeneration one must know the distance from the site of injury to the termination of the nerve as well as the time interval between regeneration and either operation or, in instances in which no operation took place, the injury. In dealing with patients, neither of these factors usually is known and must be estimated. In our cases the distances were estimated and are probably accurate within reasonable limits. The time interval was taken from the first visit to the clinic after regeneration was noted to be complete. As several weeks may have passed between visits, there may well be a large error here, but certainly the error favors a conservative estimate.

The average estimated rate in seventeen cases was 1.24 mm. a day. The extreme range lay between 3.6 and 0.58 mm. a day. The true rate is probably closer to 1.5 mm.

The nerves that were not divided and did not require suture were in large part associated with fractures around the elbow. Two of these were not operated upon, three were merely freed from surrounding scar tissue, and eight were transplanted at the elbow. Both of the failures occurred in attempts at transplanting.

Because of the fact that many of this latter group did not have complete physiological division, it is impossible to determine the rate of regeneration. However, in these cases an average interval of eleven weeks occurred before beginning regeneration was noted and it was some thirty-six weeks before regeneration was complete in the average case. The extremes lay between one and twenty-eight weeks before regeneration began and between six and eighty-seven weeks before it became complete. The times, it may be said, fairly closely paralleled the estimated distance necessary for the regenerating nerve fibers to traverse. It was in two of these cases that our only complete return of motor function occurred.

It is of interest to note that all four of the failures we have recorded were attributable to improper technic. In the first instance a neuroma, which should have been excised, was split lengthwise and the distal nerve embedded in it. In the second case the nerve was sutured under too much tension. The third case involved an accidental severance of the nerve on attempting a transplantation at the elbow; and in the last instance a nerve was transplanted that apparently had been so traumatized that a resection and suture should have been performed.

Injuries to the median nerve comprise our largest group, both in the total number and in those we were able to follow.

The site of injury was about equally divided between the palm of the hand, where usually digital nerves were cut, and the wrist. A few digital nerves were severed in fingers and a few median nerves injured in the forearm and upper arm. Unless the nerve was involved in the upper arm, serious motor impairment was limited to the opponens pollicis, for the abductor of the thumb and the first and second lumbricals are relatively unimportant muscles as regards function of the hand. It is of interest that we have seen four instances of division of the median nerve in the wrist without paralysis of the opponens pollicis, indicating, that in these instances, either the motor branch arises from a higher level than is usually supposed or

that the muscle is innervated by another nerve. In addition one patient with ulnar and radial palsy associated with a fracture developed paralysis of the opponens without other evidence of median involvement. The median nerve was explored and found intact. Function eventually returned as the ulnar and radial nerves regenerated. From our follow-up studies we have found that good function has returned to the opponens in three cases out of six. In two of the three failures, function was taken over by the adductor, satisfactory for all but the most delicate movements. The third patient who had also an ulnar paresis required a tenorraphy. In general, by the time that sensation was complete, motor function had also returned.

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TABLE III

RESULTS IN FIFTY-SEVEN INJURED MEDIAN NERVES

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	Total No. of Cases	Results Determined in		Good		Poor
		No.	Per Cent	No.	Per Cent	No.
Sutured...... ..	45	36	80	29	80.5	7
Neurolysis..	11	8	72.7	8	100	0
No operation	1	1	....	1	. .	0
Total....	57	45	78 9	37	82 2	7

The age of the patient certainly played no part in median regeneration, for while our good results averaged thirty years old, our poor results were only twenty-three.

The time interval between injury and suture was apparently more important than in the ulnar nerves. There was but one failure in ten nerves sutured within the first few hours following injury, while there were five failures out of twenty-one sutured more than three weeks following division. Only one successful suture was accomplished more than one year following injury, although five were over six months old. Sepsis again played no part, for in four instances all attained good results.

An estimate of the rate of regeneration was made as in the ulnar nerves. This was determined in twenty-one cases to average 1.09 mm. a day. The extremes lay between 2 and .50 mm. a day.

Of the nerve injuries that did not require suture all but two were associated with fractures, mostly of the upper humerus. These two followed aneurysms of the brachial and axillary arteries, and both successfully regenerated.

We could determine in only two instances when regeneration first became manifest, these were in twelve and seventy-seven weeks and regeneration was complete in fifty-two and 156 weeks, respectively. In four other patients completion of regeneration occurred in eight, seventeen, eighty-one and 104 weeks. As in the ulnar nerves the longer intervals were associated with a greater distance to be traversed by the regenerating nerve fibers.

TABLE IV

RESULTS IN THIRTY-FIVE INJURED RADIAL NERVES

	Total No. of Cases	Results Determined in		Good		Poor
		No.	Per Cent	No.	Per Cent	No.
Sutured......................	11	8	72.7	3	37.5	5
Neurolysis..................	13	13	100	11	84.6	2
No operation................	11	11	100	11	100	0
Total....................	35	32	91.4	25	78.1	7

As may be seen in Table IV we have been able to trace the results of only thirty-two injured radial nerves and of these only eight had required suture. They are an interesting group, however, for the criteria of a good result depend almost entirely on motor regeneration. The area of sensation in the hand supplied by the radial nerve is variable, inconstant and may in large part be taken over by a "spread" from the median distribution.[3] It is of interest that once we observed sensory regeneration, though Bristow[4] says it never occurs.

Our poor results in sutured radial nerves are surprising, for an average of the twenty-one authors quoted by Pollock and Davis[1] indicates that the radial nerve should have the best prognosis and the ulnar the poorest, just the reverse of our series. However, the sparsity of our cases and the fact that all but two, both of which were successful, were sutured early in the ten-year period that we are examining may account in part for the discrepancy. It is perhaps also important that all the radial nerves were severed in the upper arm, and that the axones, certainly those of the sensory component, had a rather longer distance to traverse than in the cases of the ulnar and median nerve transections.

The cases are too few to attempt statistical analysis, but it may be mentioned that the three patients with good results averaged

sixteen years of age and were operated upon one and six-tenths months after injury, while the five with poor results averaged thirty-six years of age and repair of the nerves was not attempted until eight months after injury. Both sutured nerves in the two wounds that became infected regenerated. The rate of regeneration could be computed in only one patient, in whom it was 1.2 mm. a day.

In the thirteen patients whose radial nerves at exploration did not require suture, the results were much better. It is probable that in at least one of the two poor results the nerve was so damaged that resection and suture should have been done. In all except two, these cases were associated with open reduction at which time the nerve was found caught between fragments or embedded in callus. Of the remaining two, one was involved in an aneurysm of the brachial artery and the other with a cut of the upper arm; but although the nerve was found undamaged at operation, function never returned. In this group regeneration required an average of twenty-five weeks for completion, with extremes of four and fifty-two weeks. Two of the successful results followed operation more than a year after the injury.

TABLE V

RESULTS IN FIFTY-ONE NERVES INJURED IN ASSOCIATION WITH FRACTURES

		Total No. of Cases	Results Determined in		Good		Poor
			No.	Per Cent	No.	Per Cent	No.
Radial............	Sutured	1	1	....	1	....	0
	Neurolysis	12[*]	11	....	10	....	1
	No operation	11	11	....	11	....	0
Median..........	Sutured	0	0	....	0	....	0
	Neurolysis	3	3	....	3	....	0
	No operation	2	2	....	2	....	0
Ulnar............	Sutured	2	2	....	2	....	0
	Neurolysis	15	12	....	11	....	1
	No operation	5	5	....	5	....	0
Total..........	....	51	47	92.1	45	95.7	2

In eleven cases in which radial palsy was associated with fracture, no operative interference was adjudged necessary. Surprisingly, all the patients attained satisfactory results. In some instances it is impossible to say upon what basis this judgment was made. In

several, however, it is clear that only a partial palsy was found on clinical examination and it is probably safe to conclude that many of the cases could be so classified. Three of these were radial palsies that occurred following open reduction. Nevertheless, an average of six and five-tenths weeks was required before beginning regeneration was noted on the record and it was at an average of twenty-seven weeks before function was complete.

We have considered it of sufficient interest to record separately the results of nerve injuries associated solely with fractures. (Table v.)

They have all been considered separately under the headings of the various nerves, but we have grouped them together, primarily to show how seldom it has been found necessary to suture nerves so injured and also to indicate what good results may be expected.

Both poor results have been recorded before; the radial nerve was one which presumably should have been resected and sutured and the ulnar nerve was the one that was inadvertently divided while attempting a transplantation at the elbow.

Three of the nerve injuries followed rather than preceded open reduction, in each instance the operative note mentioned freeing the nerve and gently retracting it out of harm's way. It has been called to our attention that even with the greatest gentleness and utilization of every precaution accidents such as these may occur. In one instance the radial nerve was gently retracted with a single layer of rubber tissue from which was suspended a "Mosquito Snap." Even this delicate retraction proved excessive and a radial palsy that did not clear for six months resulted. One cannot advise the policy of not identifying nerves, for many would be inadvertently severed were this followed; but it is certainly true, that once the position of the nerve has been determined, the less interference with its course the fewer will be the subsequent nerve palsies. Nerves are freed from their normal relationships to a far greater extent than is usually necessary.

In our series, no nerve was permanently injured by operation, except the ulnar nerve mentioned above. By far the greater number of these nerve injuries were treated by neurolysis. In many instances this was attendant upon open reduction, but in others the decision to operate was made irrespective of the fracture. There has always been discussion as to the value of neurolysis as a therapeutic procedure, for if left alone, say the opponents, would not most of these nerves regenerate spontaneously?

No satisfactory single test has yet been devised to determine whether a given nerve will regenerate or not. The presence of a partial palsy or reduced sensation rather than paralysis and anesthesia is undoubtedly as good an indication that waiting may be pursued profitably as any other.

Frequently, the pathological condition found at operation justifies in most minds operative interference, and we may also point to those not infrequent instances of palsy coming on a long time after fracture of which we have two cases, in one of which weakness and hypesthesia did not become noticeable for twenty-one years, as further evidence that neurolysis may be advisable. These latter are associated particularly with fractures about the elbow causing impingement on the ulnar nerve. But after all, it is only by demonstrating that function has returned to nerves following neurolysis in which a sufficient period of time had elapsed for spontaneous regeneration to take place before operative interference was undertaken that we can answer the objections to the procedure with much conviction. Of our cases, twenty were subjected to neurolysis irrespective of the associated fracture. Of these, four operations were performed more than six months following the fracture, two were operated upon at the end of a year, and on three neurolysis was done three, four and eighteen years following fracture, all with successful outcome. It is impossible to prove the value of the operation in the remaining eleven cases, doubtless in some it was unnecessary, but we feel certain that as a therapeutic procedure it has a definite and important place.

Because of the difficulties in determining the extent of nerve injury and in recognizing the presence or absence of regeneration occurring spontaneously or after operation, a special study has been made in selected cases in hopes of developing more exact methods of examination than are usually employed. The familiar clinical tests for the presence of sensory loss, weakness, atrophy and vasomotor changes are all essential and need not be enlarged upon other than to emphasize their importance in following the course of all nerve injuries. There are many occasions when these tests are not conclusive until a period of months has passed and one looks for a more sensitive means of detecting early regeneration. This situation arises particularly in relation to the radial nerve where motor return may occur before sensory changes, in combined radial and median nerve injuries in which it is difficult to separate their sensory areas because of overlap, in facial paralysis in which sensory changes are not

present and in other cases in which sensory examinations are for some reason unsatisfactory.

Electrical tests have been tried with hopes of securing more
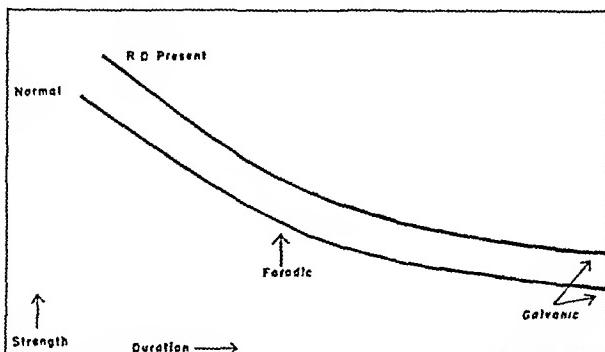
FIG. 1. Diagram showing normal strength-duration curve (lower) and when reaction of degeneration was present (upper). Galvanic response obtained as indicated by arrows. Faradic response only with electrical excitability as indicated by lower curve.

information concerning the state of the nerve, but have not solved the problem of concluding at an early date whether the nerve is completely severed or if there is regeneration. The galvanic-faradic tests for reaction of degeneration have been used for years but perhaps the limitations have not always been recognized. Since this phenomenon was described by Erb, in 1867, more complete studies have been made on electrical excitability of muscles. It has been shown that to obtain a contraction the stimulating current must have a definite strength (volts) and duration (milliseconds). There is a known relationship such that for every given voltage there must be a certain duration of current flow; the greater the voltage the less time it must be applied to obtain a liminal contraction. This relationship may be plotted in the form of a graph known as a strength-duration curve. A normal curve is illustrated in Figure 1, giving a fairly accurate visualization of the electrical excitability of the muscle tested. With degeneration of the motor nerve to a muscle there are changes in electrical excitability as is well known. The strength and duration of stimulating currents must be increased to procure a contraction and this decreased excitability is reflected in the curve as shown in Figure 1. When testing with galvanic and faradic currents one is actually determining two points on this excitability curve. The galvanic stimulation corresponds to the longest duration of stimulus and the faradic to a much shorter stimulation for each impulse. The

voltage is not measured with faradic stimulation and noted only roughly with galvanic and in both instances is limited by the tolerance of the patient as high voltages are painful. The reason a faradic
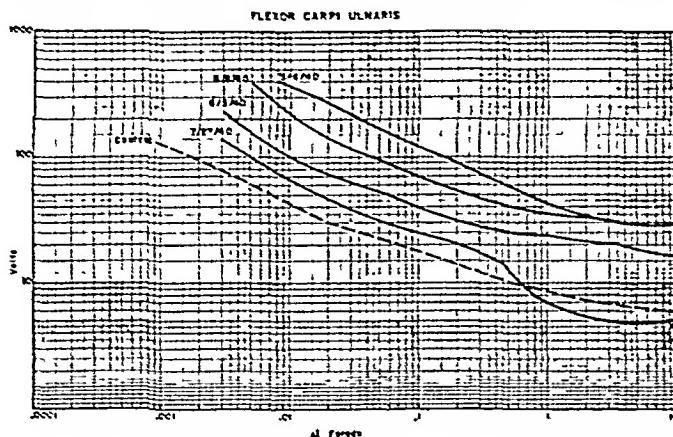

FIG. 2. Voltage-capacity curves in ulnar nerve injury showing normal control and progressive improvement in affected muscle over a four months' period.

response is not obtained in denervated muscle is shown diagrammatically in Figure 1 for with the voltage tolerated there is not sufficient duration to produce a contraction. Determining chronaxy also amounts to observing accurately one arbitrary point on the strength-duration curve from which deductions as to excitability are made. It, therefore, becomes apparent that determining the whole strength-duration curve is a more complete and accurate measure of electrical excitability.

In selected cases we have used this method of observation to follow the course of nerve regeneration or to determine the extent of nerve injury. The technic employed consisted of using either a small bore hypodermic needle as stimulating electrode or a small zinc disc with electrode paste. A large dispersive electrode was attached to the opposite pole of the stimulating machine. The end point was taken as the just visible contraction of the muscle as indicated by movement of the needle or skin over the muscle with varying strengths of stimuli. The stimulator was designed by Grass, of the Harvard Medical School, and allowed the use of stimulating currents varying in capacity from 10–.001 microfarads and in voltage up to 400 volts. Suitable series and shunt resistances were coupled in the stimulating circuit to minimize the effect of varying skin resistances. The condensers of larger capacities are known to discharge over a longer period of time and this relation of capacity to time can be expressed by a simple mathematical formula converting capacity readings

to milliseconds. In these observations, however, only the capacities were recorded and plotted against the voltage on logarithmic paper forming a voltage-capacity curve comparable to those described by
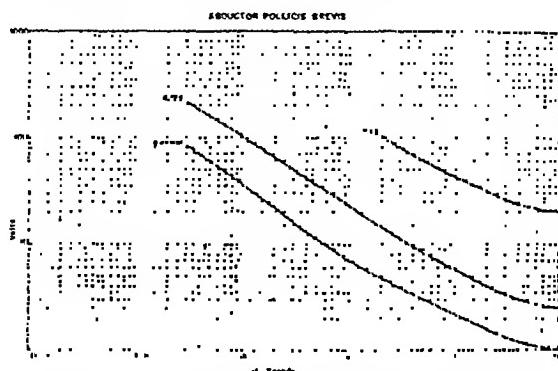

FIG. 3. Voltage-capacity curves in median nerve injury showing progressive loss of excitability.

Rosenblueth[6] in his recent studies on degeneration of mammalian muscle. Observations were made in ascending and descending order with control readings on comparable unaffected muscles of the opposite extremity when possible.

A typical normal voltage-capacity curve is shown in Figure 2. The changes effected by injury to the motor nerve are also illustrated in the same figure. This case is that of a patient with neurofibroma in the region of the elbow, but not attached to the ulnar nerve. This tumor was removed surgically with some difficulty due to local hemorrhage. Postoperatively there was complete ulnar nerve paralysis and it was not known whether this was due to inadvertent injury from instruments or to damage by hematoma. Electrograms were first done four months postoperatively at which time there was clinically no sign of regeneration either motor or sensory. Sensory testing was complicated by excessive scar tissue of the forearm in relation to the tumor and was of little value. The results of the electrical tests are illustrated and show the gradual improvement in excitability in the flexor carpi ulnaris muscle before this could be determined clinically, thus allaying fears that the nerve might have been severed.

In another case of a boy who fell on a milk bottle severing tendons and nerves in the wrist and hand the opposite results were obtained. The abductor pollicis brevis and opponens muscles were affected and these muscles were tested by the same method for signs of spontaneous regeneration. The voltage-capacity curves are shown in Figure 3

and demonstrate progressive loss of excitability from which it was concluded that spontaneous regeneration could not be expected and an operation was performed.
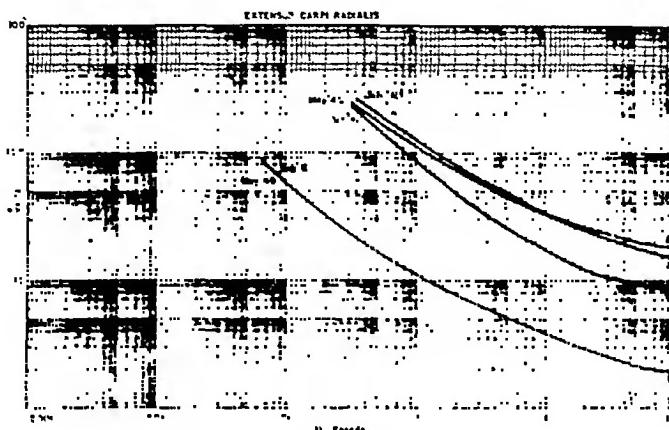

FIG. 4. Voltage-capacity curve in radial nerve injury. Curve D shows the normal control, also return to normal after one year of the affected muscle. Curves A, B and C show the course of electrical excitability in the interim.

The next case is that of a man who received a stab wound in the middle of his upper arm with resultant infection and sudden hemorrhage two weeks later for which he was operated upon. The hemorrhage was controlled but there was noted later complete radial and median nerve paralysis, these structures not having been identified at the time of operation. The problem here was to decide whether or not the nerves in question might spontaneously regenerate. The arm was splinted, the patient received physical therapy and the excitability of the denervated muscles was tested from time to time. The results appear in Figures 4 and 5. The flexor carpi radialis and extensor carpi radialis muscles were examined and interestingly the first sign of improvement was noted on the day he was scheduled to enter the hospital for exploration. This procedure was cancelled and he has gone on to complete recovery of function.

Another case was referred to this clinic for question of exploration and possible suture of the radial nerve. He had received a stab wound above the elbow five months previously with complete radial nerve paralysis and no clinical signs of regeneration. Electrical examinations were done and one month later, when repeated, showed the first signs of regeneration other than some tingling in the thumb, indicating that regeneration might be expected to occur spontaneously. (Fig. 6.)

We wish to point out and emphasize that a single examination of
the electrical excitability of a muscle will not indicate the state of the
nerve in question. For five to seven days after even complete sever-
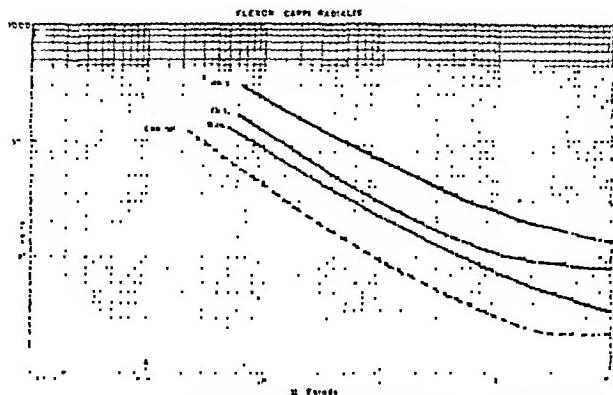

Fig. 5. Voltage-capacity curves in median nerve injury
showing progressive spontaneous improvement in
electrical excitability.
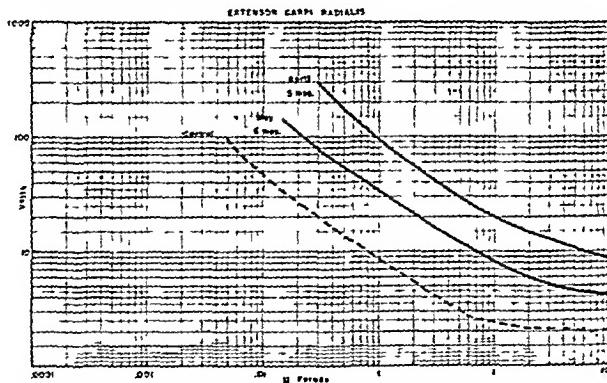
Fig. 6. Spontaneous regeneration in radial nerve injury
as indicated by approach to normal of the voltage-
capacity curve.

ance of a nerve the electrical excitability of the muscle is normal.
There then develops a progressive loss of excitability which is mani-
fested by loss of faradic response and changes in the strength-dura-
tion curves as shown. The first signs of regeneration as indicated by
electrical examination of the muscle do not appear for an appreciable
length of time, months usually, whether one tests with the faradic
coil or by the method used here. Repeated determination of voltage-
capacity curves has given us some quantitative information as to the
extent of nerve injury, whether partial or complete and also in
special cases has revealed signs of regeneration before noted other-

wise. We have the impression that sensory regeneration precedes electrical improvement, but no statistical evidence. Tinel's sign has been unreliable in a small number of cases. In the majority of cases on record careful sensory examination has been the most reliable early sign of regeneration when such a test was possible. When sensory findings were unreliable, voltage-capacity curves have been very helpful in making an early prognosis. Galvanic-faradic testing is useful in differentiating hysterical from organic paralysis and in rough quantitative estimates of the degree of injury, but of little value in detecting early regeneration.

We conclude that a quantitative method of determining electrical excitability of denervated muscle such as the voltage-capacity curve is of value in judging the extent of nerve injury, in detecting early signs of regeneration and in following the course of repair. It may also prove of assistance as an objective test evaluating the usefulness of various therapeutic procedures particularly physical agents such as heat, massage and electrical stimulation.

TECHNIC

We have neither originated nor employed any departure from standard surgical practice. We believe strongly in a careful physical examination to determine the exact amount of damage done in any fresh injury. If we see a patient within a few hours after the accident, we hope his wound has not been contaminated further by well meaning bystanders and even doctors.

One detail that we lay particular emphasis upon is the liberal use of normal saline solution. While operating upon a hand recently injured it is not uncommon to use ten or twelve liters, constantly running a stream of it into the wound. Even in an old case the incision is frequently flushed with saline and only wet sponges are used. An anatomical dissection is performed, the nerve ends isolated and carefully approximated with fine silk, care being taken that the stitches traverse only the epineurium. The question of funicular apposition is frequently raised. It seems reasonable to suppose that axones will provide better function if they are allowed to progress down their proper funiculus, and that poor function despite regeneration may be attributable to their not finding the proper pathway. However, in Bell's palsy, though there is no division of the nerve and consequently no loss of funicular apposition, regeneration is frequently only partial. At all events, the impossibility of correctly aligning the funiculi at nerve suture is very apparent at operation,

and we suggest only that rotation be eliminated as much as possible.

If the wound has been contaminated and sepsis appears likely, we still advise nerve suture; for even if the worst occurs and the suture is a failure, the ends will more likely be in apposition and secondary suture facilitated.

If the injury is an old one, the nerve ends are freed from the surrounding scar tissue and sectioned with a sharp knife until normal appearing nerve tissue is demonstrated, thus disposing of scar tissue and neuromas before suturing. If retraction of the nerve ends has been excessive or if too much damaged nerve has had to be sacrificed to make suture without undue tension impossible, even with utilization of joint mobility, one must do what one can to attain more length. This can usually be accomplished in the ulnar nerve by freeing and transposing the nerve anterior to the medial epicondyle. The median and radial nerves cannot be extended as far, but considerable length may be gained by freeing the nerve throughout a large part of its course. The most spectacular success we have attained in this manner was in the case of a twenty-one year old girl who four years before coming to us had severed both the median and ulnar nerves in the midhumerus region. No attempt at nerve repair had ever been made. At operation the proximal ends of both nerves had retracted seven inches so that they lay under the pectoralis major muscle. Freeing them for a considerable distance with gentle traction, supplied enough length so that they could be sutured with the arm in extreme adduction. Three years later she had regenerated sensation to all but the tips of her fingers and has enough motor regeneration to play the piano.

We have lately attempted to gain length by planning a multi-staged procedure. This entails suturing the proximal and distal neuromas together under rather more tension than would be desirable in a nerve suture, and, if in the forearm, with the wrist in acute flexion. During the succeeding two to six weeks, the wrist is gradually extended, thus stretching the nerve. When this has been accomplished, the neuromas can be excised and the ends approximated with the wrist again in a flexed position. This operation has been performed too recently to allow of our judging of its success. We have had no experience with the fibrin nerve sutures as advocated by Young and Medawar.[5]

All arms with sutured nerves are placed in plaster splints post-operatively. These are designed to fulfill two purposes: The first is

to ensure that no added tension will be placed on the suture line, and the second is to prevent excessive stretching of denervated muscles. We follow in large part the principles laid down by Harmer[2] on the subject of splinting.

Usually the original cast is not removed for two weeks, at which time the wound is inspected. By the end of three or four weeks the primary function of the cast has been fulfilled and the task is now one of rehabilitation. Splinting to protect the paralyzed muscles must be continued, but the position of function is now assumed and the patient sent to the occupational and physiotherapists. We believe that these two play a large part in whatever success we attain. Our patients for the most part co-operate and many return several days a week for months at a time in order to receive treatment. They are meanwhile followed at regular intervals in the Hand Clinic, where progress is noted and suggestions made for further treatment.

SUMMARY AND CONCLUSION

This report summarizes the results in 110 injured ulnar, median and radial nerves, treated at the Massachusetts General Hospital during the years 1931 to 1940. Eighty-four and five-tenth per cent were considered to have shown satisfactory end results based on arbitrary criteria. Ulnar nerves successfully regenerated in 88 per cent, median in 82 per cent and radial in 78 per cent of their total numbers.

It could not be established that the age of the patient, the presence of infection in wounds or the time interval between injury and treatment had any bearing materially upon the eventual outcome. The average rate of regeneration lay between 1 and 1.5 mm. a day.

Nerve injuries associated with fractures are discussed separately and are shown to regenerate successfully in 95.7 per cent of their total number.

A new technic of determining electrical excitability in peripheral nerves is described and methods of treatment are outlined.

REFERENCES

1. POLLOCK, LEWIS J. and DAVIS, LOYAL. *Am. J. Surg.*, 18: 579, 1932.
2. HARMER, TORR WAGNER. *Am. J. Surg.*, 47 517, 1940.
3. POLLOCK, LEWIS J. *Surg., Gynec. & Obst.*, 49: 160, 1929.
4. BRISTOW, W. ROWLEY. *Lancet*, 1: 312, 1941.
5. YOUNG, J. Z. and MEDAWAR, P. B. *Lancet*, 2: 126, 1940.
6. ROSENBLUETH, A. *Am. J. Physiol.*, 129: 22, 1940.

DISCUSSION

ARTHUR L. WATKINS (Boston, Mass.): It is frequently difficult to tell the degree of nerve damage, or at an early date whether or not regeneration may be expected to occur spontaneously, in spite of good clinical examination as for sensory impairment or motor loss, atrophy, and so forth.

This is particularly true of radial nerve injuries in which it is known that sensory losses may come after sensory return, maybe after motor return, in combined median nerve and radial nerve injuries in which the sensory areas overlap, in fascial nerve injuries in which the sensory loss is not present and in some cases in which sensory tests are not reliable.

Frequently, electrical examinations are made to give additional information, particularly galvanic and faradic testing. This has not been entirely successful. Ever since 1867, when Erb described the reaction of regeneration, there has been more learned with electrical excitability of nerves and muscles.

It has been shown that in order to get response to electrical stimulation a certain voltage of current is necessary, and also a certain type of stimulus. Therefore, you must have both strength and duration for any individual stimulus in order to get muscular contraction.

If you take stimulation with varying currents in varying durations, you can plot curves which will give an example or show just what the electrical excitability of the muscle in question is in a fairly accurate way. As you increase the voltage and lessen the time, the shape of the curve goes up. When reaction to regeneration is present, there are changes in this curve. More voltage is required and also a greater length of duration of stimulation is needed for each individual voltage required.

In other words, the curve tends to shift. The relation between these changes in the faradic and galvanic test is obtained, while with your long duration you get a response when reaction to degeneration is present. With faradic stimulation, you have a much shorter time interval of stimulation for each impulse as it comes in, and the voltage is limited by the apparatus and the tolerance of the patient, so that with faradic current you would only have an area in here where you can get a response. If you do not get a response, there is an alteration in the excitability.

We have used in selected cases a means of testing this excitability by an apparatus with which you can measure the discharges of condensers and also the voltage by meters, by using a needle electrode or occasionally surface electrodes as a stimulating electrode, and large dispersive electrodes with the other poles.

He had a case of an ulnar nerve injury of an individual who had a tumor in the region of the elbow which was removed, and there was a good deal of hemorrhage. Following this, it was noticed he had an ulnar

nerve paralysis. The question arose whether or not the nerve had been cut, or whether spontaneous regeneration might here be expected.

Excitability tests were done at varying intervals. Sensory tests could not be done, because of the extensive scar tissue over the forearm. This was our only means of telling at an early date whether or not degeneration might occur.

A couple of months after the patient was first seen, there was an improvement noted as less voltage was noted, indicating probably regeneration would recur without the need of operation.

In a similar case, but in a median nerve, there was no improvement, therefore, operation was performed.

I wish to point out, however, that even with these tests a definite length of time must be waited before signs of regeneration occur electrically. It may be a matter of months, depending on the length of distance from the site of injury to the muscle being examined. In general, the sensory tests are probably the earliest signs of regeneration. Where they are not possible or unsatisfactory, we believe that this method of testing is helpful.

F. J. Tees (Montreal, Quebec): I am delighted to see the excellent results that Dr. Hamlin and Dr. Marble reported in the care of the medians and ulnars. During the last year of the First World War, we had admitted to the Granville Canadian Special Hospital, where I was working, some 500 patients with peripheral nerve injuries. We made it a rule, of course, not to attempt treatment of these patients until at least three months had elapsed after healing, and we found that of that number, only 150 were referred for operation, which meant that a great many of these war nerve wounds would recover spontaneously.

Of the 150, roughly one-half came for suture and one-half for a neurolysis.

I have a very firm belief that the important thing in nerve suture is to get end-to-end apposition, and I think Henry Marble's seven-inch gap is perfectly wonderful. We managed to close a four-inch gap in an ulnar nerve in the forearm and thought that was pretty good.

One method that I think is of importance when a large gap is found is to do the two-stage operation; that is, first of all to free the nerve up and down, approximate the bulbs, and close up; then at a later stage do the final end-to-end suture.

What I think is perhaps the most important thing of all in attempting to do the nerve suture is to avoid rotation of the nerve. Those who have had experience in nerve suture will realize how even in the atrophied end of a nerve you can make out the little pattern of the nerve bundles corresponding with the nerve bundles at the peripheral end, and one should make every attempt to get those two patterns to correspond.

Our experience was totally different from that reported by Dr. Hamlin, because our recoveries in the muscular spiral or radial nerve were immensely better than in the medians and in the ulnars.

We thought that the reason why the radial nerve recovered so much better was because it has just a gross movement to do, that is, it is just responsible for the dorsal flexion of the wrist and fingers, while the ulnar nerve is asked to do such opposite things as separating fingers and bringing them together. If the least amount of torsion is present, one can easily see how that is disturbed.

We did have one rather interesting case which I wish to report. Our cases were always admitted to the care of the neurologist. This man was admitted with a paralysis of the deltoid muscle and he had a small wound at the back of his shoulder. Colonel Mackay, who was in charge of the medical side, had an x-ray taken which shows a little square piece of shell fragment lying behind the head of the humerus, and more as a joke he referred the case to the surgical side for, as he said, "suture of the circumflex."

We reflected the lower border of the deltoid and located that little piece of shell fragment lying on the bone. We were luckily able to find the proximal end of the circumflex and the two distal ends. The circumflex is not much bigger than the piece of lead in a lead pencil, but we were able to draw the ends together and left it at that.

To our amazement, the man had a definite recovery within thirty days after the operation, which leads me to think that the nerve makes a pretty good try to find its way down to the distal ends.

SPIRAL·AND OBLIQUE FRACTURES OF THE TIBIA*

A METHOD OF TREATMENT

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SAN FRANCISCO, CALIFORNIA

A BETTER understanding of skeletal traction coupled with the use of the fluoroscope in the closed reduction of fractures has lead to a decrease in the indications for open operation. However, with the proper surgical technic the risk associated with open reduction is so slight that one should not hesitate to operate in order to bring about those conditions necessary for rapid, complete healing and early return of function.

We do not wish to reopen the controversy regarding the selection of cases for open operation at this time. On the Stanford Surgical Service at the San Francisco Hospital we consider the danger of delayed union and nonunion following spiral and certain oblique fractures of the tibia so frequent that prompt open operation is justified. It is believed that the accurate reduction and rigid fixation attained at operation will assure early union provided early weight bearing is instituted. It seems necessary to add that such a position must be qualified according to organization, personnel, equipment and patient.

It is common knowledge that prolonged immobilization of a fracture often leads to atrophy of the neighboring musculature and fixation of joints. This explains current enthusiasm in regard to the early mobilization of joints and the early introduction of physiotherapy. It is, however, impossible to maintain complete fixation of a fracture of most long bones and at the same time institute early physiotherapy. The removal of fixation apparatus for the introduction of motion and massage results in delayed union more often than is generally recognized. On the other hand, we have come to recognize that even though it is necessary to maintain complete immobilization of joints in the vicinity of a fracture, one may avoid impairment of motion in the joints and atrophy of nearby musculature by institut-

ing early active use and weight bearing. Early weight bearing seems also to maintain the circulatory status of the part and to speed up calcification of the callus, leading to early solid bony union.

It has long been recognized that use of wire is a simple and efficient means of achieving accurate fixation in the open reduction of fractures, and that its use necessitates the introduction of a minimum of foreign material which might retard union. The disadvantages, however, have been that silver or other nonoxidizing wire was not strong enough to maintain fixation, particularly in that type in which there is no weight bearing surface at the site of fracture. Steel wire of suitable strength had the disadvantage of oxidation with reaction about it.

The introduction of rustless steel wire for the fixation of fractures soon after the use of stainless steel in the manufacture of surgical instruments seems to have overcome these disadvantages and because of its tensile strength and durability allows us to return to a simple means of internal fixation. It is important, however, to emphasize that in all types and forms of internal fixation the actual fixation of the fracture is maintained through an external splint. It was not until the advent of the nonpadded plaster cast that it became possible, even with the combination of internal and external splinting, to immobilize completely certain types of fractures to the point of weight bearing.

With these considerations in mind we have attempted to devise a means of treating spiral fractures of the tibia which will allow first, accurate reposition of the fragments, second, complete fixation of the fracture and third, early weight bearing on the fractured limb. The method of treatment outlined here cannot be called a new treatment. It is the combination of several principles previously suggested which has enabled us to work out a satisfactory method of treatment for spiral and certain oblique fractures of the tibia.

DETAILS OF OPERATION

Under spinal anesthesia a Mathews' pin is inserted through the os calcis and a properly fitting stirrup so applied as to avoid any motion of the pin in its longitudinal axis. The limb is then placed on a Böhler frame (Fig. 1A) so that the knee is flexed at right angles to the long axis of the body, with the buttock resting firmly on the operating table. A small pillow is placed in the popliteal space to prevent pressure necrosis as traction is applied to the limb through the Mathews' pin. Sufficient traction is then applied to maintain the limb

rigidly in the Böhler frame and to overcome as much shortening as possible. It is possible at this stage of the procedure to correct any rotatory deformity of the lower limb. With the leg remaining in the

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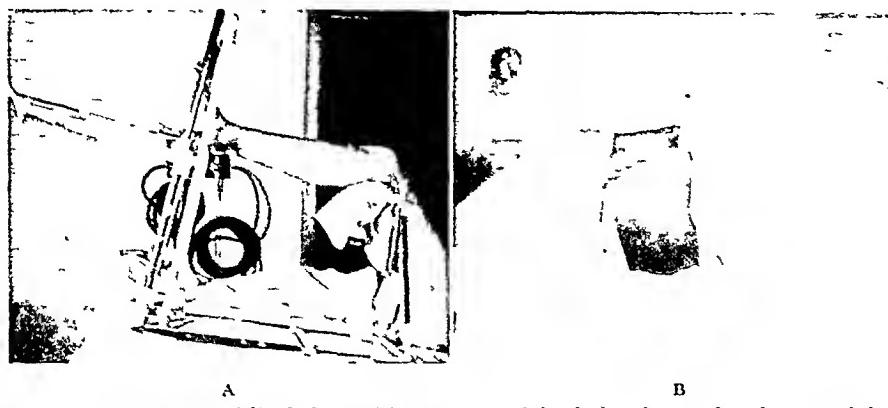
FIG. 1. A, position of limb in Böhler frame with skeletal traction in os calcis. B, limb draped in frame for operation.

frame the skin in the operative field is prepared, first by cleansing with tap water followed by the application of lime and soda which is removed with water, alcohol and ether. The skin in the immediate operative field is then prepared with tincture of merthiolate. The leg is draped for operation, leaving only that small area of the skin exposed which constitutes the operative field. (Fig. 1B.) A straight longitudinal incision is made over the anterior medial aspect of the limb at the fracture site. The skin edges are then covered with towels held in place by Michel clips. Hemostasis is not necessary because the pressure on the limb in the popliteal space against the transverse supporting bar of the Böhler frame is sufficient to act as a tourniquet. The bone is exposed by retracting the margins of the wound with hook retractors. The subcutaneous tissues separate from the periosteum without difficulty and with very little associated tissue damage.

As a rule one will find that most of the deformity, i.e., shortening and rotation, has been reduced by the preoperative manipulation in the Böhler frame. It is interesting to note how frequently one finds shreds of periosteum overlapping the spiral component of the fracture, intervention of soft parts, and, if operation has been delayed, how often one is unable to reduce the fracture completely because of the intervention of partially organized blood clots between the fragments. It is almost always possible to obtain a perfect reduction by very simple manipulation in the frame. It is imperative that the fractures be so perfectly reduced that there can be no motion at

the site of fracture, otherwise the repeated traumatization of sub-sequent weight bearing gives rise to recurring hyperemia and con-sequent decalcification.


FIG. 2. A, schematic drawing of method of placing stainless steel wire. B, roentgen examination following reduction with wire in place.

With the fragments in perfect apposition, they are held in place by a lion-jaw clamp and drill holes are made at an angle through the fragments crossing the spiral component of the fracture in such a fashion that the uppermost hole is in the proximal point of the distal fragment and the lowermost hole in the distal point of the proximal fragment. It is important, as will be shown later, that these drill holes be so placed. A rustless steel wire is then threaded through these drill holes. If perfect apposition of the fragments has not already been obtained it is a simple matter at this point, by using the steel wire as a guide, to force the fragments into position.

It is not necessary that the wire be so placed that it will prevent rotation, lengthening, or angulation of the fragments, for the application of skin-tight plaster gives us sufficient external fixation to prevent subsequent occurrence of these deformities; however, it is absolutely essential that the wire be so applied and of sufficient strength to prevent shortening. It is for this reason that we use rustless steel wire.

By placing the wire so that the upper portion of the loop is in the proximal end of the distal fragment and the lower portion of the loop in the distal end of the proximal fragment, we are able to form a steel sling at the fracture site which, with each attempt of nature to cause shortening, forces the fragments into more complete approximation. (Fig. 2A and 2B.) The wire is drawn up and twisted over the surface of the bone and its twisted ends hammered down against the bone so that they will not cause subsequent soft tissue pressure necrosis.

The advantage of having the limb suspended in the Böhler frame becomes apparent at this point. With the fragments fixed in place with a single piece of steel wire the reduction is maintained. The fixation which comes with perfect reduction is of sufficient strength to maintain the position of the fragments with the aid of the Böhler frame. The handling of the limb, ordinarily accompanying the application of plaster, is avoided. The normal physiological pull of the muscles has been overcome by the right-angle position of the leg and also by the traction in the frame. If necessary, the operation and subsequent application of plaster may be completed alone without the aid of assistants, the reduction being maintained throughout subsequent procedures, by the Böhler frame.

The wound is closed by approximating the subcutaneous tissues with a few interrupted catgut sutures and the skin with interrupted black silk sutures. A small tincture of benzoin dressing is placed over the wound and held in place by a few turns of sterile sheet wadding. It is imperative that this dressing be as slight as possible in order not to interfere with the application of the skin-tight plaster.

The leg is now ready for the application of the plaster cast. A long posterior plaster splint is prepared of 4″ bandage of sufficient length to extend from the tip of the toes to the junction of the upper and middle thirds of the thigh. This splint is firmly molded to the posterior aspect of the leg and the plantar surface of the foot by the application of a circular flannel bandage. We do not direct the turns of the flannel about the leg but allow them to follow their "natural course" so that no constricting areas will result. It is important that a narrow bandage be used and that it be so applied that the flat surface is always flush with the skin; this necessitates frequent cutting but in the end the application is smooth. (Fig. 3A.)

The fixation of the posterior plaster splint in this manner is carried out from the tip of the toes to the popliteal space. With the limb still in the Böhler frame a circular plaster bandage is then, applied to the lower limb. Particular care is taken to mold the plaster to the leg in order to avoid subsequent pressure. It is advisable to mold the plaster about the ends of the Mathews' pin in order that the plaster will completely fix the pin in place. During the time of application of plaster to the lower leg one must take care that the part of the posterior plaster splint which extends from the popliteal space to the thigh be kept moist by constant kneading and re-wetting.

As soon as the plaster on the lower limb is set the limb is removed from the Böhler frame and the knee extended. The upper part of the

posterior plaster splint is molded into the popliteal space and onto the posterior aspect of the thigh and circular plaster extended above the knee joint to the junction of the upper and middle thirds of the

Fig. 3. A, application of posterior splint and cast to lower leg in frame. B, long leg cast after extension of the knee.

thigh. (Fig. 3B.) When the plaster is set, before it has dried, it is split throughout its entire length, along the dorsal surface to allow for postoperative swelling. In cutting the plaster away from the dorsum of the toes, when the cast is trimmed, one should be certain that the plaster on the dorsum of the foot remains intact up to the webs of the toes. This will prevent painful herniation due to postoperative swelling of the loose areolar tissue at this point. It should be noted that in every patient upon whom we have operated in the Böhler frame, the circulation, as indicated by the color of the toes, has returned immediately following removal of the limb from the frame.

AFTER-TREATMENT

During the first forty-eight hours following operation it is well to keep the limb elevated in bed. A postoperative anteroposterior and lateral film is taken as soon as possible following operation. If the fragments are in perfect apposition, the Mathews' pin is removed from the heel. The cast remains in place, with the limb at complete rest for two weeks following operation when it is removed.

During these two weeks of fixation the patient is encouraged to exercise the quadriceps and the flexors and extensors of the toes within the cast. At the time of removal one usually finds that there has been considerable loosening of the cast because of the reduction in the swelling of the limb. By this time the wound is completely healed and the silk sutures may be removed. It will also be noted that as a general rule there is sufficient fixation at the point of fracture to allow the patient to raise the extended limb from the bed

without support. A nonpadded plaster cast is now applied including the lower leg and the thigh to the junction of its upper and middle thirds. A walking iron is applied to the cast and from this day on the


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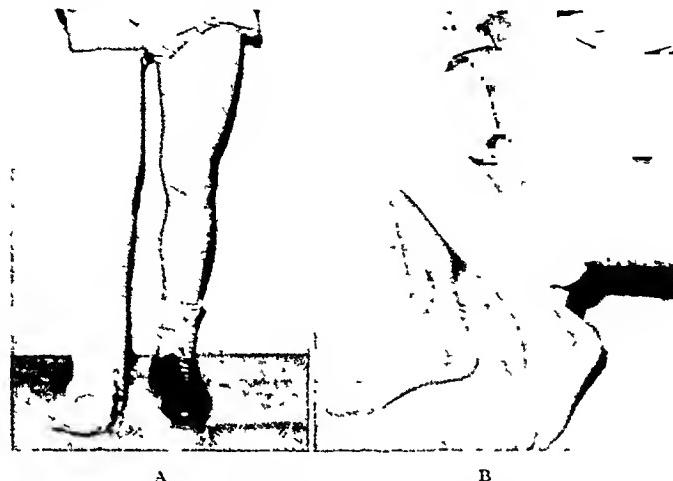
FIG. 4. A, long leg walking cast applied ten days after open reduction. B, knee joint flexion to 90 degrees immediately after removal of walking cast.

patient is not only allowed but encouraged to bear full weight on the affected limb within the limits of pain. (Fig. 4A.) If the cast has been properly applied and if the internal fixation with wire has been properly performed, the patient is soon able to bear full weight without pain and usually with the aid of only one crutch. It is possible for this patient to return to his work providing his occupation is such that it does not necessitate standing. The walking cast remains in place for six weeks. If at any time during these six weeks plaster becomes loose, it is removed and re-applied.

Complete bony union of the fracture is as a rule obtained at the end of this period. In case there is any question of bony union at the time of removal of the walking cast a new cast should be applied immediately. It will be noted that upon removal of the walking cast there is, as a rule, only slight atrophy of the musculature of the limb and that motion in the ankle and knee joints is only slightly limited. (Fig. 4B.) It is only at this stage of the treatment that active physiotherapy, i.e., massage, active and passive motion, should be instituted. The return of complete function with the use of these methods is very prompt.

MATERIAL

A total of 132 spiral fractures of the tibia comprise this group. Seventy-four were treated according to the method described,

twenty were treated by means of skeletal traction above and below the fracture site with fixation in a plaster cast, eighteen were treated by means of a single traction pin through the os calcis and fixation in a cast, and eighteen by simple reduction and a long-leg plaster cast. Seventy-two per cent of the patients were males. The ages ranged from three years to eighty-two years, the average being 36.7 years. None of the patients in the younger age group were treated by open operation. In children there is rarely an associated fracture of the fibula and consequently very little if any displacement of the fragments of the tibia. This group is best treated by simple immobilization. The youngest patient operated upon was fifteen years of age.

In the entire group there were seven compound fractures, two of which were compounded from the inside out. This is not difficult to understand when one realizes that the mechanism of injury in this type of fracture is almost always one of indirect violence. The two fractures which were compounded from within were the result of weight bearing immediately following injury. The remaining five resulted from external violence.

The interval of time between the accident causing the injury and admission to the hospital varied from a few hours to twenty-four days; the majority, however, entered the hospital on the day of the accident. An effort was made, provided the condition of the patient and the fractured limb warranted it, to institute local treatment at once.

In that group of seventy-four patients treated by open reduction whenever possible, the operation was undertaken as an emergency procedure immediately following admission. In a small group of patients, operation was delayed because of the patient's general condition or because of open wounds in the immediate vicinity of the fracture line. The blebs and blisters and the excessive swelling so commonly noted following this type of fracture were not considered contraindication to immediate operation inasmuch as the contents of blebs are sterile and swelling subsides very rapidly following the rigid fixation and accurate reduction associated with open operation.

Those patients treated other than by open operation were so treated because the tissues locally would not warrant open operation, because the patient fell into the younger age group, or because the patient came in on a service which wished to try more conservative means of treatment. This segregation of patients has fortunately served the good purpose of allowing a comparison of end results.

RESULTS

In the seventy-four patients treated by open reduction and wiring according to the method described, all operative wounds healed *per primam* with the exception of two. In these two infection occurred on the fifth postoperative day. The wounds were opened and packed with vaseline gauze without disturbing the immobilization. In both cases healing was retarded; however, in both healing took place within five months. In the patients operated upon, the period of immobilization in plaster was from eight to twelve weeks, and the average total period of disability fourteen weeks from the date of operation. In this group there was one case of nonunion. This occurred in a thirty-seven-year old female who was discharged from the follow-up clinic sixty-seven days after operation with "good union" and "a good functional result." She returned two years later with a nonunion at the site of fracture. After removal of the steel wire and drilling of the fracture site, prompt healing occurred. It was necessary to remove the wire in two additional cases because of local irritation. These wires were improperly placed at the time of operation.

In the remaining sixty-eight patients treated by closed reduction, even though they include eighteen cases in which the patients were fourteen years of age or younger, the average period of immobilization in plaster was five months and the average total period of disability seven months. In this group there were eleven cases of nonunion, three of which occurred in patients treated by means of simple casts following reduction, and eight of which occurred following the use of two pins, one above and one below the fracture site. We are of the opinion that this method not only does not allow weight bearing at the fracture site, but often maintains distraction, which is a frequent cause of nonunion.

SUMMARY

1. A method of treating spiral and certain oblique fractures of the tibia is presented.

2. A summary of seventy-four cases in which the patients were treated by this method is presented, together with sixty-eight cases in which other methods of treatment were used.

3. A comparison of the end results of treatment has been made.

DISCUSSION ·

Kellogg Speed (Chicago, Ill.): This is an important contribution with a well grounded mechanical background. To discuss Dr. Mathewson's paper I would like to mention a point lightly touched by him in the opening paragraph when he said that with proper surgical technic the risk associated with open reduction is so slight that one should not hesitate to operate in order to bring about these conditions necessary for rapid complete healing and early return of function. From the standpoint of his activities and surroundings this is so; it may be so for every member of this association, but in spite of the rapid spread of well taught surgical technice in university hospitals we must admit that over 90 per cent of all fractures occurring in this country are still handled by practitioners. These men doing only occasional surgery cannot be expected to have either highly developed surgical facilities nor the ready-at-hand surgical technic and ability to perform open operations on the tibia. Have we reached the point in hospital development and control of men practicing surgery where we wish to encourage this practice nationally?

When and if such fractures can be transported within a few hours to the hands of a qualified surgeon, then possibly no one could object to open reduction of the difficult oblique and spiral fractures. They fall into a class of too easy secondary displacement even when treated with bone transfixion followed by skeletal traction and plaster embedding although the primary reduction may have appeared eminently satisfactory. I agree that exact reposition may control and yet assure callus effort and that thoughtless physiotherapy may endanger the result. Early weight bearing likewise may ensure a follow through to mature callus formation but I am not acquainted with any proof that it speeds it up in physiological time. With weight bearing axial replacement of the bone must be guaranteed along with the apposition of the fractured surfaces and if the external fixation does not meet this demand, the bending and possible rotation at the weak fracture sight will prolong healing. Hence the firm fixation by the internal splint plus the nonpadded, glove-fitting plaster encasement in combination may hold definitely.

In the details of the operative technic I wonder at the necessity for the lime and soda application removed by water, alcohol and ether. Dr. Mathewson uses tap water but does not mention soap in the primary cleansing. In many clinics soap and water after shaving followed by 80 per cent alcohol to remove some of the superficial water is considered adequate preparation. Perhaps the thoroughness of any method of preparation is the secret of its success, but it should remain as simple and cheap as possible. We do not find that tinctures of any antiseptics will penetrate more than one layer of superficial epithelial cells once they are engorged and water swollen.

spite of the effort by this method to avoid shrinkage of muscle and
rts, we see that a secondary cast for ambulatory purposes is an
al factor. In that regard the method may fall short of an ideal pro-
Many of us may, however, adopt this ingenious fixation as an
-get, inexpensive substitute for metal plates and the paraphernalia
d in their application. The results appear highly satisfactory and
e compared in time and quality with those obtained by surgeons
igid internal fixation by plates alone, disregarding external splint
t. As the controversy for and against external fixation after internal
g ages we seem reduced to the conclusion that we are still dealing
e virtue of concentrated attention of the man giving treatment rather
ny one definate method of treatment.

ARNOLD GRISWOLD (Louisville, Ky.): Dr. Mathewson was kind
to send me a copy of his paper. There are a great many things in
which I agree and a few with which I heartily disagree.

not think that we have to do open operations on the great majority
al oblique fractures of the tibia and fibia. I think we can put a great
nto plaster and walk them very early without internal or external
, except for the plaster cast. Some more of them we can put into
a with pins above and below. I should also like to state that, in that
tion, pins above and below the fracture can be used not only for
tion or traction and countertraction of the fragments, but they can
l for control in all directions and, if necessary for compression of the
e. Distraction, of course, is one of the dangers of powerful mechan-
thods, and it does produce delayed union.

principal thing that I admire in Dr. Mathewson's paper is a very
principle which applies to the open operation on all bones, whether
e arm, the forearm, the femur, the leg, or the spine; that is, an opera-
any bone should be carried out under traction and with the bone in
sition in which it is going to be fixed after operation is complete.
his method you do not have to put the leg or arm into the hands of
stant to hold while you are putting on a cast. This disturbs the
nship and increases the stresses on your plate, or your wire, while
e applying external fixation.

iink the most important principle that Dr. Mathewson has brought
hat of operating upon the fracture in traction, and I should say, in
sition in which it is to be fixed afterward. He operates with a flexed
. should prefer to do it in traction with the knee straight, in the
n in which it is to be fixed after the operation is complete.

RAY MURRAY (New York City): It can be said that the ideal
treat a fracture is to wish the fragments into place, and hold
there by moral suasion and let the patient go right on about
iness.

The degree of efficacy of any method of fracture treatment is to be gauged by how nearly it approaches this ideal. It is based on the principle that if you cannot do good, for Heaven's sake, don't do harm.

This method approaches that ideal. The sling principle of preventing the deformity of over-riding, and by limiting that deformity during weight bearing, of actually encouraging accurate approximation of the surfaces, is ingenious, logical and sound. The only criticism which I have to make of this procedure is this: It might be epitomized in this phrase, "Why send a boy to do a man's errand?"

It is perfectly possible to fix bone fragments today by the proper observance of sound mechanical principles, so rigidly that active motion of all the joints involved, plus early weight bearing, can be instituted without external fixation, in other words, a nearer approach to sending the patient about his business.

The principles involved in this procedure are absolutely correct; but if one is going to expose the patient to what is commonly branded the terrific risk of an open reduction of a fracture, if one is going to put fixation elements into the bone, I cannot understand why the fixation apparatus must consist of something which will prevent deformity *provided you tie the extremity up in plaster.*

The procedure, if one is going to operate and if one is going to fix the fracture, is not logical if it requires in addition external mobilization. The claim is made that because of this method of fixation, it is possible to institute at least partial function, that is, of weight bearing. There are methods just as safe if you are going to do an open reduction and fixation, which can be used, which will install full function rather than partial function. I, therefore, approve of this procedure in principle, but from my own standpoint I believe that once you get in, if you are going to fix the fracture you might just as well fix it adequately, enough to be able to leave off the external plaster.

I have been told very emphatically by numerous people that the function of the lower extremity is weight bearing, and that if you immobilize a joint for from six to twelve weeks (if I did not misunderstand the terms of this paper), five minutes after the plaster is off they have function of the knee and ankle joint. I find myself unable to take any patient out of plaster after twelve weeks and get his knee to a right angle if it has been at 180 degrees for twelve weeks.

Now, the knee of this particular patient unquestionably was at right angles in five minutes. I do not know how much he enjoyed it. But if you take the run-of-the-mill patient and put him in plaster with a knee straight for twelve weeks, it has been my experience that motion of the knee is restored very gradually.

Not that you cannot eventually get function of the knee. But I object strenuously to talking of a patient in terms of eventual function. These

patients have wives and children, the vast majority of them. The question as to whether it takes three months to get their function back or three weeks is an important proposition, not to the doctor but to the patient.

I believe that as long as you are going to operate, and as long as you are going to practice fixation, then you ought to practice the type of fixation which allows you to continue not partial but as nearly complete function as possible.

In addition this man required a pin through his os calcis. It is not without risk. I think, taking things by and large, the method is sound, but it goes only part way.

HERBERT M. BERGAMINI (New York City): I was not aware that I was to enter into any discussion until this morning, so I do not feel fully prepared to say anything.

Dr. Mathewson came to me this noon and briefly outlined his paper. All I can do is to repeat what Dr. Magnuson said in regard to Dr. Murray's paper—he was sorry he could not put up an argument. I rather fall in line with all that Dr. Mathewson has presented.

His rather uncommon sense and not so-called common sense use of mechanical principles is worthy of the attention of all of us. It is quite similar to a method we have been using for just this type of spiral-like fracture in the lower extremity in which we use quite similar mechanical principles in putting not a plate but a wire (stainless steel No. 22 gauge) barrel-like hoop about the fracture site.

Then we follow, I might say, the most uncommon sense principle of distracting slightly these spiral oblique fractures on the principle of the inclined planes, tying the encircling loop snugly, so that, as the inclined planes or the spiral fracture becomes non-distracted, the wire hoop becomes snugger and accomplishes much the same purpose that Dr. Mathewson accomplishes by his reverse oblique insertion of those wires. Dr. Mathewson's method is a very clever procedure.

In concluding I feel the urge to tell this story which is circulating around Washington: Quite recently a telegram arrived at the White House addressed to no one less than the late Honorable Woodrow Wilson. This is alleged to have arrived last week. It read: "Mr. Wilson, don't look now, but we think somebody is following you." I think somebody is following me.

CARLETON MATHEWSON, JR. (closing): I have not very much to say. Seeing is believing. It is true that many of these joints will not flex to 90 degrees immediately after removal of the cast, although this man's did, and he was sixty-five years old. However, a large majority of them will if they bear weight on their fracture as they are instructed to do during the period of healing.

We know that this occurs in the knee joint and in the ankle joint, regardless of what Dr. Murray has to say, because we have observed it in a large number of patients. I might say if we were going to Dr. Murray

to have your fracture treated, it would probably be a good idea to have it plated. If you came to me, it would probably be a good idea to have it wired. If you go to Dr. Griswold, it would probably be a good idea to put pins in it.

I was hurried in my review. We had, at the same time that we treated these fractures, an equal number of patients on the other side of the ward, being treated by double pins and by plates. The number of non-unions and infections were much greater in this group.

I have a patient in the hospital now who walked for fifteen years by means of a plate, before it became infected and was removed. He now has ununited fracture. We have all seen these cases, and that is why we object to the use of plates.

I object to two-pin traction because a large percentage of people who use this method will distract the fragments, not in the sense that they are pulled apart in the longitudinal axis, but rather they will maintain rotatory distraction which leads to delayed union and non-union. In many of these cases periosteum has fallen between the ends of the bone, so that even though they are reduced they will not heal.

I would like to thank these gentlemen for discussing the paper.

CONVALESCENT CARE OF PATIENTS WITH FRACTURES*

ROBERT H. KENNEDY, M.D.

NEW YORK, NEW YORK

A PATIENT with a fracture is commonly convalescent from the moment his fracture has been reduced and the method of fixation decided upon and effected. He enters the hospital a broken man, not a sick man, physically or mentally. It behooves us to see that he does not become ill during his convalescence. The less he is put in the same category with the sick patient, and rather treated as a person who was perfectly well an instant before the accident and expects to stay well, the shorter will be the period in which he needs convalescent care. The solution of the problem for the patient with a fracture and the general hospital is not more beds of the ordinary convalescent type. These do not keep a well man well. His institutional convalescent care, however, concerns the general hospital, the out-patient department and the organized convalescent institution.

As a general hospital occupant, this type of patient is too often conditioned to become an invalid during his stay. Frequently he requires prolonged care to recover from his hospitalization rather than from his injury. A young man has done heavy labor in construction work for several years. He is a superb physical specimen, proud of his ability to lift more than any other man in the gang, proud of the wife and youngster at home and of the pay check he brings in each week. Suddenly a cave in occurs pinning his thigh between rocks, which causes a fractured femur. Can we justly place this man in the same group as one recovering from a severe illness? Rather we must try to keep these young, finely trained muscles and this care-free brain in as good a condition for six to twelve months as they were two minutes before the accident occurred. This does not mean lying in bed for weeks gazing at the ceiling, except during the periods when an attractive attendant serves his food and bathes him. He begins to worry about funds, the family, his injury, his job. Gradually he softens physically and mentally. The punch is gone. This

hospital life is rather comfortable anyway. Let someone else worry about his family; he is not going back to work until he is absolutely fit. Beside he has a good case against the company, didn't his lawyer say so? If we are not careful, even with a perfect surgical result, our man is liable not to return to his work for three or four years, if ever. Let us not be a party to producing unemployment. This is not convalescence from a fractured femur, but from a hospital stay, too often spent under conditions far more luxurious than those to which he has ever been accustomed. Our major effort in the early convalescent care of patients with fractures should be made from the point of view of prevention of the need of convalescence from "hospitalitis."

Special wards for fractures help greatly. It is not well for the man with a fracture to be in the same bed for three months, while on each side of him one patient after another with acute surgical conditions come in for ten to fourteen days and then go their way. It produces a feeling of frustration as he quickly becomes the oldest inhabitant of the ward. In a fracture ward he will encounter different stages of similar lesions—one man learning to use a walking caliper, another just wrestling with crutches, one being congratulated by his fellows on his first time out of bed in several weeks, another on having his traction wire removed, etc. These men are all playing the same type of game and they encourage and train one another. The new patient, meeting a proposition for the first time about which he knows nothing, rapidly falls into the routine of a fracture ward, becomes interested in the progress of the others and looks forward to his being able to do these things himself as soon as possible. Further, he is a well man among well people. Years ago it was customary to see a plaster spica applied, and then, as far as the visiting staff was concerned, the patient was passed over until the time arrived for removing the plaster. This is somewhat less frequent than formerly. Much harm to the patient results and this is another valid reason for insisting on a fracture ward. Place a doctor in charge who is really interested in fractures and you will see things begin to move. If your beds for acute surgical cases are clogged up with fracture patients, you may find that, while your visiting staff is greatly interested in abdominal work, no one is taking responsibility for making certain that the patient with a fracture is having the advantage of the most up-to-date and speedy care.

Early physical therapy to the injured part, commenced on the day of admission, is a most important part of convalescent care. We

cannot take space to go into this here. But there is much which can be called physical therapy, that should be supervised by doctors and nurses rather than technicians. Take, for example, the case in which plaster has been applied to the forearm and hand in a Colles' fracture. If applied properly, it extends to the metacarpophalangeal joints only, so that all fingers can be moved completely. Too often no one thinks to tell the patient to move his fingers. Weeks later a physical therapist works hard to gain recovery of a function which would never have been lost, if someone had insisted on the patient moving his fingers many times a day from the first day on.

At Beekman Hospital we have found class exercises of great value in the fracture ward. Because one leg is injured there is no excuse for allowing the muscles of the neck, back and three other extremities to deteriorate and greatly prolong the convalescence. Suppose on getting out of bed a patient will have to use crutches. Would he not prefer to have two strong arms and one strong leg to support him? Each afternoon one of our physical therapy technicians comes into the fracture ward, turns on a phonograph to march time and leads the men in simple calisthenics as they lie in bed or sit in a chair. All uninjured parts, or those not actually immobilized, are exercised by the whole ward together, with the technician actually instructing and leading—neck, back and the four extremities in segments. It was difficult at first with men who had never done such a thing. But once started it became a simple routine, since the new admission was ashamed not to play the game as he saw his neighbors doing. The men look forward to it now and there is no doubt that it has helped the morale of the ward as well as its physical status.

The social service department has a large opportunity in convalescent care while the patient is still in a bed on an acute surgical ward. Probably the patient had no neurosis at the time of injury, at least not a sufficient one to keep him from working. Every effort must be used against his developing one during convalescence. What are his home conditions? What are the means of support of his family? Exactly what did his work consist of? Is there the probability that he will be able to do precisely similar work? If not, with the type of mentality he has, what work could he adapt himself to? Does his employer want him back and can he expect an opening when he is ready to return? Is his family of the type which will baby him when he returns home and make him worse? If his injuries are severe and it is unlikely that he can return to a similar place in industry, is he a man who wishes to work, or will

he be satisfied to remain a cripple? Does he believe society owes him and his family a living, whether working or not?

The social service status has to be investigated and put into writing during the first few days after injury. No neurosis has been established then. This is the time to survey the problem as thoroughly as possible so that adjustments to his environment may be suggested before the problem really arises or becomes fixed in the man's mind. If we let the man who has always been a good worker become a social service problem, have we not much to answer for if we did not try to appreciate the gravity and extent of our problem in the first few days after injury?

Many persons seem to do excellently while hospitalized, but their whole mental attitude apparently changes shortly after discharge. *Is it the constant solicitude of their family? Is it contact with an attorney? Is it the effect of a compensation board hearing?* At any rate, we should urge the social service department to do all it can in the early days to fortify the reaction of the patient against the effect of these contacts. We must accept a certain responsibility for allowing a well man to develop into a partial or complete invalid while convalescing under our care. We have no right to treat the injured part only and stop there.

Convalescent care in the out-patient department is a serious problem. In many instances the patient is seen by a different doctor than attended him in the hospital, or even by a different doctor each day. The patient often comes to question whether anyone is really interested in his injury. Here again the social service department can accomplish much by continuing the work which it started in the hospital.

The treatment often tends to be routine, e.g., "physical therapy three times a week," with a check up by the doctor every one, two to four weeks. Physical therapy can only help the patient to help himself. Many patients are never told that their half hour two or three times a week is but a minor part of their convalescent care. They must be shown definite forms of exercise and urged to do these literally hundreds of times a day. If these can be purposeful occupations instead of mere calisthenics, they are much more effective.

The usual convalescent institution means little in the treatment of fractures. To the city patient it means a vacation in the country and little more. It is questionable whether he is helped by mingling with other types of patients at these institutions. The patient who had an acute surgical condition will return to his normal life sooner

and his actual working parts have probably not been affected. The same is true of the patient with an acute medical condition. The patient with a fracture is liable to develop a feeling of inferiority in comparison. It is a question whether the patient with a chronic medical condition will return to active life, and his association with the patient who has suffered a fracture may lower the latter's morale and make him think he is an invalid also. The same idea holds for association with the patient who has cancer or with one who represents a chronic orthopedic problem.

The patient who has sustained a fracture needs work therapy, not a vacation, but a hardening process. The usual convalescent institution is not conducive to this. Work should be started in the hospital. Ways and means should be devised to keep his mind and body occupied from the start. He should not be treated as a star boarder but as a perfectly well man except for one cracked-up part. If it is brought to the nurses' attention and properly supervised, the patient can help with many things in ward work without disturbing the morale.

Occupational therapy should be introduced much more widely in general hospitals. There are several excellent schools training persons to teach this. The great difficulty is to keep it from developing into a routine rather than using one's imagination to make the best adaptation for the individual patient. Doctors in general cannot know how to do this, but they should recognize its value, know when it is well done and back it enthusiastically. Occupational therapy is many times more valuable than the usual types of physical therapy in these patients. Even without a trained instructor and a shop, much can be done in a simple way if some one is interested in doing it.

I question gravely whether the usual convalescent institution should be used for patients with fractures and whether they may often suffer more harm than any good which ensues. At the same time I believe the ideal fracture treatment would be to institutionalize the patient from the time of injury until he returns to his usual work, or to another job for which he has been rehabilitated. This does not mean that he sleeps there or necessarily eats there. It would mean economy to all concerned if there was real supervision. At present such an arrangement is practically nonexistent.

It would mean that a well man coming to a general hospital with a fracture would not be treated as if he were ill, but as a convalescent from the start. He would be taught how to use all joints and muscles in the region of immobilization, commencing on the first day. He

would be started immediately on general exercise to preserve the musculature which he brought with him. He would be given a job to do while in bed, which would occupy body and mind and make him feel he was still a part of a moving world. As soon as he was out of bed, he would be taught some form of occupational therapy similar, if possible, to what he did before he was hurt. As soon as he is fit for discharge from the hospital, he would be an ambulatory patient, if his home conditions could possibly warrant it. If not, we should arrange for institutions where the injured are by themselves and where everyone gets work therapy. This should also be true of our out-patient departments. The patients with fractures should be gathered into those institutions where they can receive work therapy. This should be daily and for an increasing time up to a full working day. At present the ambulatory patient receives the least supervision at just the time when guidance means the most to his future economic life.

There are a few rehabilitation clinics in this country and they are doing an excellent job. But they rarely see a patient until many months after injury, and frequently only when there is a question as to how much of the disability is physical and how much functional. We need many more of these clinics, but I believe that, except in the permanently crippling injury requiring a change of occupation, the convalescent care of patients with fractures could be much better handled with work therapy from the day of general hospital admission with institutionalized supervision until again ready to work. We are wasting a tremendous amount of money and man power by treating a broken bone and letting a well man get sick physically and mentally while under our care. Then after the damage is done, we spend months, years or a lifetime trying to bring him back to normal. The development of institutions adequately manned to furnish real work therapy is an urgent need in the proper care of the tremendous volume of injured persons.

DISCUSSION

FRANK D. DICKSON (Kansas City, Mo.): I think this paper of Dr. Kennedy's is an extremely timely one. We are gathered here and have been listening to methods of treatment as far as the fracture itself is concerned, and we are learning of more and more methods all the time. There is, however, great danger that we will become so preoccupied with the actual setting of the fracture and its local treatment that we will forget, as Dr. Kennedy has pointed out, about the human being with whom we are dealing.

I think there is nothing costing industry more money than the unfavorable mental attitude which the injured are so likely to acquire for just the reasons Dr. Kennedy has given. He has, as usual, covered his subject so splendidly that I do not think I could add much to it in the way of discussion.

I agree with him thoroughly, of course, as you all do, that segregation of the injured or fracture cases is of primary importance, and that your physical therapy should be started early and not late. By "physical therapy," I think we should understand that we do not mean merely putting on lights, which seems to be the most general physical therapy today. We mean physical therapy.

Certainly if adequate immobilization of the fractured bone is one of the fundamentals of fracture treatment, then keeping the joints adjacent to that fracture completely mobilized is almost as fundamentally important. That is where physical therapy comes in.

Occupational therapy is splendid. I believe the best occupational therapy is getting a man back to some kind of work. We find that those industrial groups who will permit you to send a man back to work, even if it is not back at the old job, just to get him back to work get better results than when the man is not accepted for work until ready for full duty. Under the former circumstances the man will get back at his old job sooner than the one in whom peculiar quirks in his mental makeup are allowed to develop.

Dr. Kennedy did not tell us how to avoid just one important thing, that is, how to keep the lawyer away from the man. He did not tell us that, and that is what I should like to know. Until the man is so favorably impressed mentally with his progress it is dangerous to allow the legal aspects to enter in. I would like then to know how to keep the lawyer away from him.

I do believe we have got to exercise a very definite interest and supervision of these men, as you say, Dr. Kennedy, until they are back at work. They are your patients until they are back on the job.

A. WILLIAM REGGIO (Boston, Mass.): Sometimes there are disadvantages in being at the end of the discussion when the speaker has done such a beautiful job on a subject which is extremely important, and the first discusser has kicked the remaining props out from underneath you.

I do feel very strongly just as Dr. Kennedy and Dr. Dickson have said, that the rehabilitation of the patient by means of physical and occupational therapy is of the utmost importance. One trouble is that many of the doctors who want to get their patients back at work do not know how to get them back. They do not know enough about physical therapy or occupational therapy. If I am wrong, correct me, please.

We all should go to those departments and learn for ourselves how it is being done. Then we can help those patients ourselves more intelligently, and see more clearly what is to be accomplished.

There are four big hurdles that have to be taken in getting these people back to work: There is the question of supra-orbital stenosis on the part of the patient, which is a very important factor. They do not understand what it is all about.

Then, of course, there is "compensitis," which is a very difficult disease to treat except with some paper that has writing on it. Then the thing that must be instilled into those patients—and the fellow to do it is the doctor who is in charge of the case—is the will to get well so that they will co-operate. Practically every patient that we see whom we want to get back onto the job should be told that 85 per cent of the success depends on his own effort. We can do a certain amount, about 15 per cent, but the rest the patient must do himself.

Then, the physical therapist and the occupational therapist must work more closely hand-in-hand than they do. At present, there is still a little rivalry between the two types of treatment, whereas it ought to be hand-in-glove.

At the Massachusetts General Hospital where we have a Physical Therapy Department and an Occupational Therapy Department now, the Physical Therapy Department in the past six months had ninety-nine cases, seventy-two of which were fractures of the arms and hands and twenty-one were fractures of the legs. Fifty-four of them went to the Occupational Therapy Department in co-operation.

You can get somewhere if everybody works together, but the doctor in charge of the case must keep hold of the reins and keep on steering that patient. He cannot merely refer him to the department, no matter how good a department it is, because *that* patient knows *his* doctor, and pays more attention to what *his* doctor says than to what the other department may say.

I want to see Dr. Kennedy's musical exercises sometime. I can see him swinging from balkan frame to balkan frame, teaching the patients how to do it. It takes a lot of organizing and you must have the funds to carry out the work.

As Dr. Kennedy has covered the ground so thoroughly this is about all I can say. I am very pleased to have been given the opportunity to discuss this paper which is on a subject much more important than is frequently realized.

SPINAL CORD INJURIES*

ANALYSIS OF SIX CASES SHOWING SUBARACHNOID BLOCK

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IT has been common practice to perform laminectomy upon patients with acute compression injuries of the spinal cord in which there was an obstruction of the subarachnoid space as shown by the Queckenstedt test. The purpose of the laminectomy in most instances has been to relieve pressure on the cord, supposedly arising from edema which followed the trauma. It has been theorized that the alleged edema produced impairment of circulation of the cord with resulting progressive damage. We have been unable to find any case in our records in which we believed laminectomy had served a useful purpose in cases of this type.

Four years ago, it was decided to study carefully those cases with compression injuries of the spinal cord with subarachnoid obstruction who came under our observation. Six such cases have been studied. This paper will present observations made on these six patients which present strong evidence that laminectomy is not indicated in the acute stages of injuries of this type. Cases with bony deformity or with compound wounds present a different problem and are not to be discussed in this paper.

CASE REPORTS

CASE 1. E. M., a white male, age forty-one, was admitted to the Good Samaritan Hospital on August 7, 1939, with a compression fracture of the sixth cervical vertebra sustained in an auto accident. He was transported seventy miles to Cincinnati, arriving three hours after the injury. There was complete motor and sensory paralysis below the second rib and of the ulnar surface of both forearms and hands. There was also retention of urine and complete absence of reflex activity below the level of the lesion.

X-rays showed a compression fracture of the sixth cervical vertebra without dislocation. A lumbar puncture released blood tinged fluid and showed a complete obstruction to the Queckenstedt test.

The physician who had seen him immediately after the accident was confident that there was some sensory function preserved in the right leg at that time. On the basis of this, a laminectomy was immediately done.

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The laminae of the fifth, sixth and seventh cervical vertebrae were removed. The lamina of sixth cervical vertebra was badly comminuted. The dura was intact. There was no intraspinal clot. The cord at the level of the disc between the sixth and seventh cervical vertebrae was ecchymotic and swollen. On palpation, the cord was found to be markedly softened and pulpy. Cerebrospinal fluid was obtained from above by jugular compression. A catheter was passed downward without meeting resistance. The dura was left open.

As soon as the patient was removed from the operating table, the lumbar puncture was repeated. There was still a complete obstruction of the sub-arachnoid space. The block persisted for two days, but on the morning of the third day the dynamics were normal. He had had no manipulation during the interval, except that required for the care of his skin. This patient died at home three months afterward of urinary sepsis. There was no autopsy.

Comment. This case was significant, for the obstruction of the subarachnoid space persisted for two days after laminectomy but cleared up on the third day.

CASE II. C. H., a white male, age twenty-one was admitted to the Good Samaritan Hospital on July 4, 1938, after having been injured in a diving accident three hours before we saw him. He had evidence of a complete lesion below the seventh cervical dermatome, and x-rays showed a fracture dislocation of the sixth on the seventh cervical vertebra. There was a complete obstruction of the subarachnoid space as shown by the Queckenstedt test. Skeletal traction was applied by means of Crutchfield tongs with fifteen pounds over one pulley. The following morning, fourteen hours after the accident, there was still subarachnoid obstruction, though the block could be overcome by prolonged jugular compression. A laminectomy was then done, and the cord decompressed. Immediately after operation, the block was still complete. Forty-eight hours after operation, the Queckenstedt test was normal. Death occurred on the sixth day as a result of respiratory failure.

Comment. It is interesting that the block should have cleared up on the third day in this case as well as in Case I.

CASE III. A negro, male, age thirty, fell down an elevator shaft, and was admitted to St. Elizabeth's Hospital, Covington, Kentucky, on December 30, 1938, with a fracture dislocation of the fifth on the sixth dorsal vertebra, and with evidence of a complete cord lesion below this level. We saw him twenty-four hours later. X-rays showed moderate compression of the body of the fifty dorsal vertebral, with an oblique fracture of the body and slight lateral displacement. The laminae were fractured, and they appeared to be pushed into the canal. There was a complete obstruction as shown by

the Queekenstedt test. A lamineetomy was done beeause of the depressed laminae. At operation the laminae were not found to be depressed to any appreeiable degree. The eord at the level of the injury was complete pulp.

It was planned to do a Queekenstedt test immediately after operation, but no sterile monometer was available so it was deferred until the next day. At that time, there was no obstruetion. This patient sueeumbed on the thirty-fourth postoperative day with general sepsis from decubitus ulcers. There was no autopsy.

Comment.   In this instance, we credit the operation with possibly relieving the obstruction, but it should be remembered that forty-eight hours elapsed before this was established.

In the first two cases, the subarachnoid block did not disappear as shown by the Queckenstedt test until the third day. In the third case, which occurred in the dorsal area, the block disappeared within twenty-four hours after operation was done. It will be recalled that this was forty-eight hours after the injury had taken place. We were of the opinion that the block had subsided spontaneously, perhaps contributed to in part by the removal of the posterior wall.

In each of these cases, there was complete absence of normal cord structure at the level of the injury. This has been previously mentioned by many authors, particularly Thompson[1] and Coleman.[2] In such cases, the apparent normal contour of the cord so often seen after removal of the posterior wall is, in fact, nothing more than complete disintegration of tissue held in molded form by a limiting pia which is not torn. The first two cases cited, we believe, show conclusively that laminectomy does not always serve its purpose of relieving obstruction of the spinal subarachnoid space in compression injuries of the cord.

Having presented these cases to show that the obstruction may not disappear immediately following laminectomy, we would like to present in brief two other case reports of patients who have had obstruction of the subarachnoid space on admission, and who have, over a period of three or four days, reestablished normal circulation of the cerebrospinal fluid although no laminectomy was done. These also had complete lesions and have shown no recovery of function.

CASE IV.   K. I., a white female, age twenty, was admitted to the Deaconess Hospital, Cincinnati, Ohio, on December 28, 1938, after having been injured in an automobile aecident. At the time of admission, there was eomplete loss of function below the level of the sixth dorsal dermatome and evidence of a bony deformity of the fifth dorsal vertebra. In addition to

this, there were extensive lacerations about the scalp and face, several fractured ribs, and the patient was in profound shock. Immediately after admission, the wounds of the scalp were irrigated and closed loosely, and infusions of glucose and normal saline begun. Two transfusions of 500 cc. of citrated blood each were given, and within a few hours, the shock had been overcome.

A lumbar puncture was then done which showed a complete obstruction of the subarachnoid space as demonstrated by the Queckenstedt test. The patient's general condition made laminectomy inadvisable; and since her clinical findings indicated a complete physiological lesion of the cord, it was not done. The following day the lumbar puncture was repeated. The obstruction was still present. On this day, we were able to obtain x-rays of her spine, which showed a fracture dislocation of the fifth dorsal vertebra with some lateral displacement of the superior fragments. There was also an oblique fracture line through the body of the fifth. There was considerable agitation by a member of her family, who was a physician, to have a laminectomy done at this stage, and requested a consultation by Dr. John Caldwell of Cincinnati. He agreed with me that the laminectomy was futile and incurred the risk of the patient's life due to extensive associated injuries. On the third day, the lumbar puncture was repeated and it was noted that the obstruction was not complete. On the fourth day she was placed in a bed over an extension frame, but before doing so a lumbar puncture was again done with a completely normal response to the Queckenstedt test. This patient is alive but has had no return of function.

Comment. This case is recorded because of the spontaneous disappearance of the subarachnoid block in this instance, taking place on the fourth day, whereas in two of the three cases cited previously, the obstruction persisted until the third day even though laminectomy was done.

In this case, as in certain others, we have been criticized by friends and relatives for not operating, and have been told by several prominent neurosurgeons that the family and the patient often times accept a hopeless prognosis more resignedly after operation has been done. We have not considered the emotions of family and friends as a worthy indication for surgery.

CASE v.   A white female, age twenty-two, was admitted to St. Mary's Hospital on June 5, 1940, with a compression fracture of the sixth cervical vertebra without dislocation. The bony alignment was good. There was, however, complete sensory and motor paralysis below this level. The tendon jerks at the knees and ankles were absent. There was a subarachnoid block. This patient was thought to have a complete transverse physiological lesion of the cord, and it was believed that operation was not

justified. Crutchfield tongs were applied with fifteen pounds of traction over a single pulley. Within twenty-four hours the block of the subarachnoid space had disappeared.

Comment. The relief of obstruction in this case may have been affected in part by the traction, but certainly the degree of bony deformity was not great. Whatever the cause, whether it was spontaneous or the result of traction or both, swelling of the cord subsided to the extent that the circulation of the cerebrospinal fluid returned to normal within twenty-four hours after the injury without laminectomy. This patient is alive but has had no return of function.

CASE VI.   M. W., a white female, age fifty-seven, was admitted to Christ Hospital on March 8, 1940. At the time of admission, this patient was suffering with considerable pain in her neck with radiation of pain and numbness into the ulnar distribution of her hands. She was unable to move her legs and had retention of urine. There was marked reduction of all forms of sensory function below the third rib, and in some areas of the legs there was complete anesthesia. A lumbar puncture done shortly after admission showed complete obstruction of the subarachnoid space. She was placed at bed rest without traction because the family would not authorize this procedure. By the following morning, her condition was considerably improved. She was then able to move the toes slightly but could not lift her legs from the bed. There was normal sensory function above the umbilicus, and numerous patches on the legs in which sensation appeared normal. There was still retention of urine. A lumbar puncture was not done on this day.

By the third day, her clinical improvement was marked. She could raise her legs from the bed and had normal sensation. There was still a block of the subarachnoid space as shown by the Queckenstedt test.

At this stage she was complaining of pain in her neck with radiation of pain into her hands. It had been suggested prior to this that Crutchfield tongs be applied to the skull for traction, but her son objected to the idea, and it was not carried out. However, after considerable discussion, consent was obtained, and traction with fifteen pounds over a single pulley was begun on the fourth day. Within a few moments after this was instituted, the pain in her neck and arms disappeared, and the following morning, she had almost normal function in her legs, though she still had some hyperesthesia in the ulnar distribution of her hands. The lumbar puncture on this date showed a normal response to the Queckenstedt test.

Comment. Here again it is possible that the skeletal traction may have affected the cerebrospinal fluid dynamics. It is significant,

however, that the patient showed progressive recovery of function despite the presence of a subarachnoid block.

SUMMARY AND CONCLUSIONS

We have presented the data from six cases of major compression injuries of the spinal cord, and have shown that laminectomy does not in all cases relieve pressure on the cord, insofar as it can be demonstrated by the Queckenstedt test. It has been shown that obstruction of the subarachnoid space may disappear spontaneously, and that the cerebrospinal fluid dynamics may return to normal in patients not operated upon in about the same period of time as in those upon whom laminectomy was done. It is already well known that correction of bony deformities may relieve pressure upon the cord, and in two of our cases, this may have been accomplished by means of skeletal traction. In one case, however, the obstruction was definitely relieved spontaneously before any manipulative treatment.

To justify laminectomy as a method of treatment in acute spinal cord injuries, one must assume that several conditions prevail: First, that as a result of pressure on the cord, progressive damage is being produced or recovery is being delayed because of amnoxia of that portion of the cord; second, one must assume that the operation accomplishes its purpose of relieving the pressure; third, that relief of pressure will not occur spontaneously; and finally, one must assume that this is the best method available for the purpose desired.

It must be granted that edema may cause impairment of circulation of the cord although the excellent clinicopathological work of Thompson[1] associated with his experimental data indicate that the maximum damage to the spinal cord occurs at the time of impact and is not progressive. There was a slight difference of opinion between Allen[3] and Thompson[1] concerning the lesions produced by compression injuries to the cord. Allen[3] believed that there was extravasation of blood into the cord substance, and that this produced progressive damage from edema over a period of four hours at which time the maximum destruction was reached. He did not believe that this could be altered by taking away the posterior wall of the spinal canal and opening the dura, but that it could be arrested only if operation were done within the first four hours, the posterior commissure split and the intramedullary blood and necrotic tissue evacuated.

The Queckenstedt test is, of course, not an infallible means for determining the presence of pressure upon the cord, for it has been demonstrated that the response to jugular compression will be normal as long as the lumen of the subarachnoid space is not less than the bore of the needle used (Poppen and Hurxthal).[4] Consequently, it is possible for local pressure to be present without obstructing the canal. Fragments of bone and protrusions of intervertebral discs might produce local injury that would require laminectomy. In addition to this, there are cases on record that have shown progressive loss of function that were reversible by laminectomy. We have not encountered such a case. We realize that the result of the Queckenstedt test must be correlated with the clinical findings in making any decision for surgery.

We are convinced from the observations of this small group of six cases that the result of the Queckenstedt test should not influence one appreciably in selecting cases for laminectomy. We would consider laminectomy indicated in compression injuries of the cord only if there was an incomplete lesion and the patient were showing progressive loss of function, and the loss of function could not be arrested by closed manipulation.

While the immediate observations of this paper are derived from the six cases referred to, the opinions expressed above have necessarily been influenced by the experience of one of us (F. H. M.) in the treatment of twenty-eight other cases with acute spinal cord injuries without obstruction during the past four years, and a much larger group observed over a six-year period prior to 1937.

REFERENCES

1. Thompson, J. E.: Pathological changes occurring in the spinal cord following fracture dislocation of the vertebra. *Ann. Surg.*, 78: 260, 1923.
2. Coleman, C. C. Determination of local compression as an indication for laminectomy in acute injury of the spinal cord. *J. A. M. A.*, 85: 1106-1109, 1925.
3. Allen, A. R. Remarks on the histo-pathological changes in the spinal cord due to impact. An experimental study. *J. Nerv. & Ment. Dis.*, 41: 141-147, 1914.
4. Poppen, J. L. and Hurxthal, L. M. Normal cerebrospinal fluid dynamics in spinal cord tumor suspects. *J. A. M. A.*, 103: 391-393, 1934.

DISCUSSION

Arthur R. Elvidge (Montreal, Quebec): I feel quite unable to discuss this paper in the place of Dr. Penfield. However, being an obedient servant I have come anyway. Dr. Mayfield is a friend of mine, and I am sure he believes that I am a friend of his, and at the same time, being friends, I am sure he does not expect me to agree with everything that he has said.

ribs or even with os purum, so that I think there are many advantages to an exploration; and though I think probably Dr. Mayfield may be correct in many cases, I do not think laminectomy should be laid aside too readily and in too many cases. I would prefer to call it an exploration rather than laminectomy, so as to cover the various points.

Tom Outland (Harrisburg, Pa.): As a mere orthopedic surgeon, I assure you I feel very humble in attempting to discuss this problem which in the past, at least, has been regarded as a purely neurosurgical one. However, living in a community which is on the edge of the hard coal mining region and on two main highways, I, of necessity, come into contact with a considerable number of these patients.

I usually accept, as the basis for exploratory or decompression laminectomy, whichever you want to call it, the presence of a complete block or, in rare instances, without a complete block, those in which the x-ray shows what appears to be a depressed fracture of the lamina which I assume might be pressing insufficiently to cause a complete block.

My experience, as far as the results are concerned, has been very uniform. I have never seen a patient in my own hands (and there is little in the literature that would lead me to believe otherwise in other hands) with complete transverse lesion of the cord, show any important recovery. On the other hand, I have never failed to see one with an incomplete lesion show some or complete recovery.

The conclusion which might be drawn is that the prognosis in a given case is determined at the time of the injury, and that the subsequent treatment, assuming it was not actually harmful, had little to do with it.

I like very much the temperate tone of Dr. Mayfield's paper and, as a matter of fact, see no reason why discussion regarding this subject should be heated, since both groups—those who approve laminectomy and those who oppose it—are tarred with the same brush in that the results are very unsatisfactory.

A METHOD FOR CLOSING A TRAUMATIC DEFECT OF A FINGER TIP

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THE hand is injured in one-third of all industrial accidents,[1] the fingers being involved in many of this group. Loss of a finger tip is not an infrequent injury and in many individuals it is a seriously disabling one. A typist, musician, electrical worker or skilled mechanic is greatly handicapped by the loss of a finger tip and further disabled by the thin, easily ulcerating, painful scar which often results after the healing of these wounds. A method of surgical treatment which will lessen the disability in these injuries, restore the part to a nearly normal condition and reduce the time of healing is worthy of consideration. In this paper there is presented a method of restoring a defect of a finger caused by accident. Only the early cases are reported, the secondary ones presenting scars of healed wounds for excision and grafting are not included.

We first used this method on April 28, 1921. A kitchen employee of the hospital had the tip of the left midfinger shaved off when he put his hand in a moving coffee grinder. Figure 1 illustrates the nature of the injury. A flap was sutured to the tip of the finger from the palm of the hand in the manner shown in Figure 2. The final result showed a finger with no disability, normal sensation in the grafted area, and scars that were scarcely visible at the tip of the finger and in the palm of the hand. Figure 3, a photograph taken in 1939 eighteen years after the accident, shows the result of operation.

Later, in 1923, one of the stenographers of the hospital slammed a door on her left midfinger. The tip of the finger was pinched off. She reported to the hospital the following morning and a graft from the palm of the hand was sutured to the defect in the finger. Again the result was good. November 6, 1926, she wrote, "The scars on both the finger and the hand are so faint now that it is hard to tell anything has been done to the finger. No one ever notices it unless I should happen to call their attention to it. I type with it all the time now and it never bothers me in the least." Figure 4, a photograph taken in 1926, shows appearance of finger two years after operation.

The method was not again used until a few years ago. Now nearly all our finger tip defects are treated by this method.

In 1926, Gatewood[2] reported a similar method which he used to
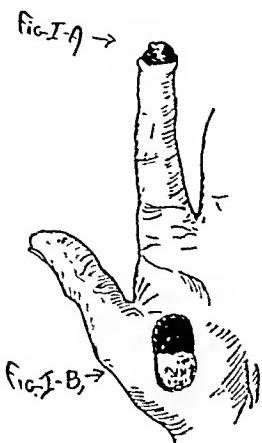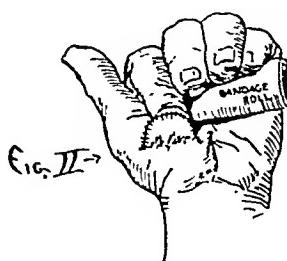
FIG. 1. FIG. 2.

FIG. 1. A, traumatic defect at tip of index finger; B, flap raised from thenar eminence.

FIG. 2. Flap sutured to tip of index finger.

cover a defect in the palmar surface of the distal third of the finger. He mentioned the fact that at that time the Thiersch graft was the most popular method of closing these defects of the fingers and hand, but thought that the graft was not serviceable because it remained thin and adherent. He believed that full thickness grafts had too few takes except in the hands of a few surgeons. Figure 5 shows a diagram taken from Gatewood's article.

In looking through the literature for the past decade we find that these wounds are still closed by free grafts such as the Thiersch, Thiersch-Ollier (split grafts), and full thickness grafts, by tube grafts from the skin of the chest or abdomen or by sleeve or pocket grafts from the abdomen, hip or some other area. Gilcreest[3] has described an amputation of the tip of the distal phalanx in which the remaining two-thirds of the nail are preserved and all the soft parts remaining after the injury are sutured to the nail. Lauten[4] placed the finger in a pocket graft over the crest of the ilium and used a graft from the crest to restore the lost bone. With the exception of Gatewood's article, we did not find any mention of using the skin of the palm of hand as a source of the skin flap.

It has been our experience that Thiersch, split grafts and full thickness grafts do not fill the defects as adequately as the flap from the palm of the hand which carries the underlying fat. The flaps from

other parts of the body while excellent for the dorsum of the hand and fingers are of a different texture and color than the palmar skin, are more easily traumatized and do not give a good cosmetic result.


FIG. 3. E. R. Photograph taken October 27, 1939, eighteen years after accident shows result at tip of midfinger and on thenar eminence.

The objection which might be offered to taking a graft from the palm of the hand is that there is no skin to spare in this region and that the resulting scar in the palm is in itself disabling. Another objection is that in some of the older individuals, keeping the finger immobilized to the palm of the hand for two or more weeks is liable to cause contracture of the joints of the finger. Although we have not a large number of cases to report, we believe we can state fairly that if one pays attention to detail in the operation and after treatment, these complications will not occur or be serious enough to offset the good features of the method.

As a working rule it is considered that these wounds are contaminated up to twelve hours and that after that time infection has

already taken place. Therefore, we do not usually accept these cases for reconstructive and plastic operations after the twelve-hour period.

Fig. 4. E. C C. Three years before this photograph was taken patient slammed door on tip of left midfinger. Graft from thenar eminence was sutured to tip of finger. Note faint scar on thenar eminence.

Most of these injuries to the finger tips occur in men who are working at the time of the accident. The fingers and hand are often covered with grease or other material with which the patient has been working. We have found that equal parts of chloride of lime and sodium bicarbonate mixed into a soft paste with water makes an excellent cleaning agent. The wound is kept covered with sterile gauze and the remaining fingers and hand are gently massaged with the mixture, after which the hand is washed with sterile water poured from a pitcher. After the hand has been dried with a sterile towel, ether and then alcohol are used, followed by tincture of iodine and alcohol, equal parts. This preparation is not allowed to enter the wound but comes up to the edges of same.

The finger is anesthetized with a 2 per cent solution of procain, the digital nerves being blocked in the proximal third of the finger. Next the wound is gently washed with pure soap and water, followed

Steps in operation
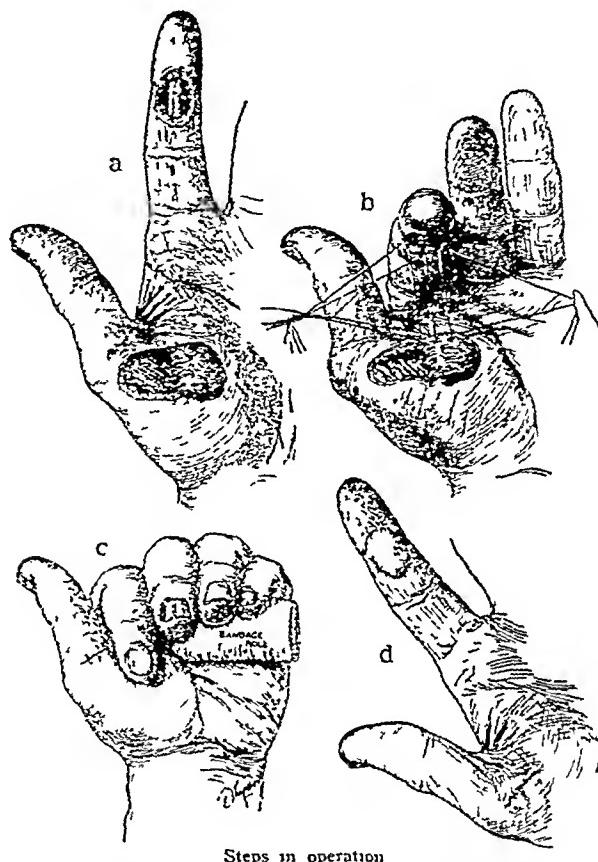
FIG. 5 Diagram shown in Gatewood's article. (From Gatewood, J. A. M. A., 87: 1479, 1926.)

by sterile normal salt solution. A débridement is then done with a sharp scalpel. All foreign material is removed with the tissue to which it is clinging and all devitalized and mangled tissue is excised so that only healthy, viable tissue remains. If the nail is missing and the nail bed badly damaged, it is completely excised. If there is a fracture at the tip of the terminal phalanx, the loose fragments are excised and the tip of the phalanx rounded off smoothly. If the digital arteries continue to bleed after the application of fine hemostats, they are ligated with triple No. ooo plain catgut with only two knots, the ligature being cut close to knot. However, we avoid as far as possible putting any catgut into the wound. During the operation the wound is bathed in a 1 per cent solution of chloramine-T. We do

not use mercury compounds because the lime and soda and tincture of iodine preparation followed by mercury antiseptics have caused skin rashes.
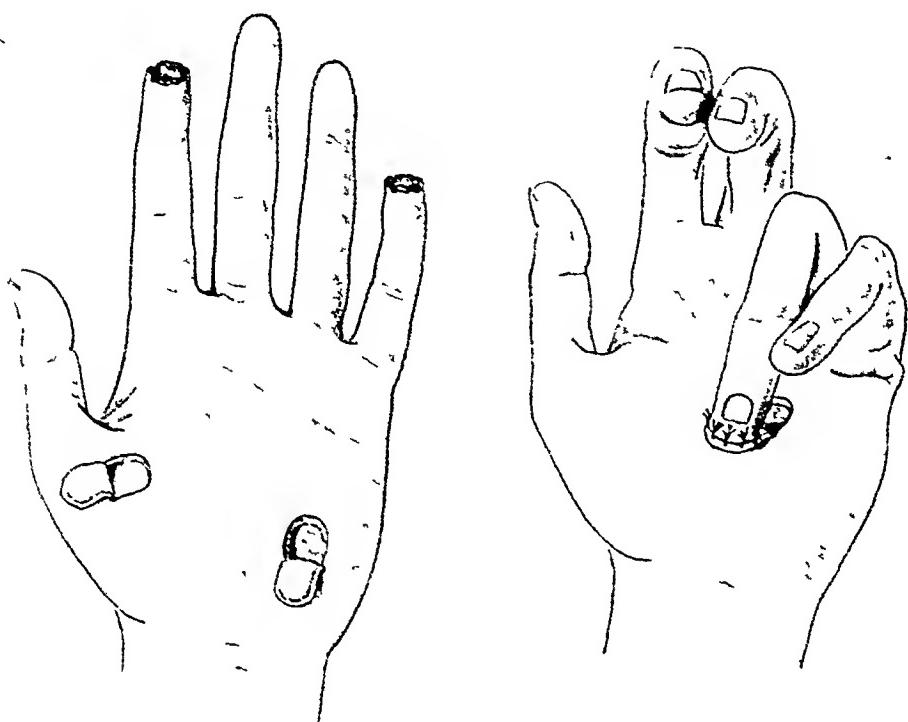
FIG. 6. 1, Pedicle laterally; 2, pedicle proximally. This illustration shows the flap raised from the thenar and hypothenar eminences. The flap avoids the creases and the mobile distal half of the palm.

FIG. 7. Shows the graft sutured to defect in finger tip. There must be no tension on sutures and no kinking in graft where this runs from graft onto finger.

The finger tip is flexed against the palm and a pattern of the defect is thus made on the skin of the thenar or hypothenar eminences. This area is next anesthetized with 2 per cent procain and the flap raised with the pedicle proximally or laterally, whichever is more convenient. (Fig. 6.) Skin flaps should not be taken in the palm of the hand distal to the thenar and hypothenar eminences. Here the skin is mobile and moves with the fingers. Also, there are important creases which incisions should not cross. The flap must be wide enough to cover the defect without tension and when raised as long as the defect. As much fat as necessary is raised with the skin. Figure 6 shows the flap raised from the palm. The finger is now approximated to the palm and the distal end of the graft is sutured to the skin between the defect and the nail, to the nail itself, or to the skin

of the dorsum of the finger depending on the nature of the wound. (Fig. 7.) The sides of the graft are sutured to the sides of the defect as far proximally as possible without tension or kinking of
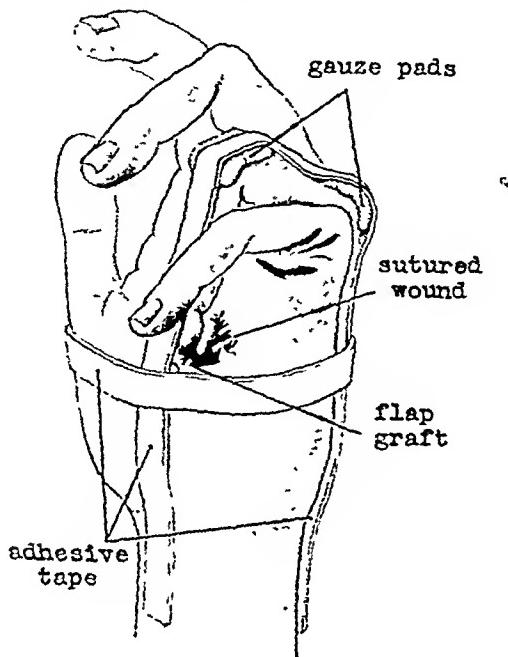

FIG. 8. Shows the suturing of graft to defect completed. The wound in palm caused by raising flap has been sutured. Adhesive tape which has been passed through the flame of an alcohol lamp has been applied as illustrated. A dressing of vaseline gauze is passed between finger and palm to cover wounds. A light layer of gauze is placed over finger and the hand bandaged. A padded board splint is applied to dorsum of hand and forearm and extremity kept elevated in an arm sling.

the graft. An assistant keeps the finger approximated to the palm until the end of the operation. Care must be taken that there is no tension on the sutures and no kink in the graft where this runs from the palm of hand onto the finger. We use horsehair sutures for most of the suturing, but an occasional fine silkworm gut suture is used where added strength is necessary. Next, the defect in the palm caused by raising the graft is sutured with light silkworm gut. These sutures must not come too close to the base or pedicle of the graft because of the danger of constriction or pressure. (Fig. 8.) A light gauze

dressing is placed over the wound. Figure 8 shows the suturing of the graft to the finger tip completed.

The finger is held in position with adhesive tape which has been

FIG. 9. T. N., age forty-three, a fisherman. About 10 P.M., October 19, 1939, left little finger was struck by a closing window, the end of finger being cut off. He entered the hospital at 1 A.M. October 20, 1939. X-ray films showed a crushing fracture of distal extremity of third phalanx, nail missing. On October 20, a first stage autoplasty was performed and on November 16, the second stage was done. On November 16, 1939, the patient was discharged to out-patient department, San Pedro, California.

run through the flame of an alcohol lamp. One strip of tape starts on the back of the hand and runs over finger and down onto the palm and lower forearm. A pad of gauze is placed over the knuckles where the adhesive tape passes over them in order to prevent pressure sores. The finger is further immobilized by adhesive tape running transversely across the distal third of finger and also across the first longitudinal strip. (Fig. 8.) A light pad is applied and the finger

bandaged to the hand. It is necessary to remove only the outer dressing in order to inspect the graft. Thus the graft, finger and hand may be inspected at any time without any disturbance to the opera-

A   B

FIG 10. A and B, photographs of same hand seen in Figure 9 taken November 6, 1941. Note scar on hypothenar eminence.

tive field. A basswood splint is placed over the dorsum of the hand and forearm and the extremity is kept elevated on a pillow while the patient is in bed and in an arm sling when the patient is up and about. The splint and elevation of the limb are very important in the after-treatment.

The sutures are removed about the tenth to twelfth day, the wounds carefully cleaned with ether and alcohol and the adhesive tape reapplied to the finger. In two weeks to eighteen days after the operation the graft is detached from the palm. Local anesthesia may be used again, but gas inhalation anesthesia or pentothal intravenously are frequently given. The granulation tissue at the tip of the finger and on the undersurface of the graft is excised. The skin

edges are slightly undermined and a slight amount of skin is excised around the margin of the wound. The wound in the palm of the hand is closed in a similar manner. The graft is now sutured to the remaining portion of the defect with horsehair sutures. Sometimes a rubber band drain is placed in an angle of the wound. The joints of the finger are manipulated and the finger completely extended. A light dressing is applied and the finger bandaged with the joints in slight flexion. The basswood splint is again applied and the arm kept elevated. Sometimes a moist dressing of aqueous azochloramide or chloramide-T solution is applied to the wound. Two or three days later

TABLE I

SHOWS THE NUMBER OF CASES, THE RESULTS AND DURATION OF TREATMENT

TOTAL NUMBER OF CASES — 18.

	GOOD	FAIR	POOR
Result on finger tip	16	1	1
Result on donor site, palm of hand	16	2	—
Contracture of finger	One with slight non-disabling contracture but two other fingers of same hand also contracted.	Two cases rather slow in recovery of complete extension of finger.	

Duration of Treatment: Average number of days   = 43
Maximum number of days   = 80
Minimum number of days   = 28

the wound is dressed. It is seldom infected, but occasionally there is a collection of serum between the wound and the graft. This is irrigated away with a medicine dropper filled with aqueous azochloramide, and a few drops of a solution of azochloramide in triacetin 1–500 injected under the flap. In a few days the wound becomes dry. The same treatment may be used in the wound in the palm of the hand. In a week to ten days the joints of the finger may gradually be extended. The sutures are removed after the tenth day. After the fourteenth day the hand is cleaned and washed with soap and water. A day or two later there is a desquamation of the outer layer of the skin over the graft and a pink healthy looking skin remains. If there should be any delay in the complete extension of the joints of the

finger, this may be corrected by applying a board splint to the dorsum of the hand and forearm and placing a wide rubber band over the terminal phalanx of the finger. It is well to place a pad between the finger and the rubber band. We have not yet had any serious or disabling contractures of the joints even in our older patients.

In a few weeks sensation appears in the graft. With use of the finger irregularities in the graft and the scar tend to smooth out and later disappear, so that in many cases it is difficult to see where the graft was placed. We have not yet had any painful scars or neuromas develop.

Table 1 shows the number of cases, the results of treatment, complications and duration of treatment.

SUMMARY

A method of closing a traumatic defect of a finger tip is described. This method more nearly restores the covering of the finger tip to a normal condition than any other procedure because palmar skin and subcutaneous tissue are used.

As in all plastic methods attention to detail is necessary, but the technic is not difficult.

The duration of treatment, much of which may be done in the out-patient department, is as short in the average case as most other methods of treating these injuries except amputation. About thirty to thirty-five days are necessary in the average case.

REFERENCES

1. Accident Facts. Page 19. Chicago, 1938. The National Safety Council, Inc.
2. GATEWOOD. A plastic repair of finger defects without hospitalization. *J. A. M. A.*, 87: 1479, 1926.
3. GILCREEST, EDGAR L. Plastic operation for repair of traumatic amputation of end of finger. *Surg. Clin. North America*, 6: 539–554, 1926.
4. LAUTEN, W. F. Finger tip reconstruction, a new operation. *Indust. Med.*, 8: 99–100, 1939.

DISCUSSION

EDGAR L. GILCREEST (San Francisco, Calif.): Dr. Jones' paper is a very worth while contribution to the surgery of trauma even though it concerns itself with nothing more than the restoration of the tip of a finger. This, however, to a person who has lost it, is exceedingly important.

His method recommends itself because of its simplicity and further because it can be used so frequently. This accident occurs often in industry

but perhaps more often in the home. The flap of skin from the palm which Dr. Jones uses makes an ideal full thickness graft for the finger.

In 1926, I described in the Surgical Clinics of North America a restoration of the tip of a finger in which one-third had been lost by traumatic amputation. With rongeur forceps I bit off the bone until a flap of tissue on the palmar surface could be brought up, covering the bone. With a small, curved cutting needle threaded with silkworm-gut sutures, this flap of skin was brought up over the bone and the needle was passed through the remnant of the nail. Five sutures made a satisfactory approximation. I had never sewed a flap of skin to nail before and did not know that it would adhere below. I was delighted, therefore, at the end of a week, to see that this flap of skin had grown beneath the nail and after removal of the sutures there was no separation. I have not been able to find any case in the literature in which soft tissues had been sewed to the base of the nail. Six weeks after the operation she was able to play a piano, using the stump of the amputated finger just as well as the other fingers. The end of the finger, which at first had a blunt, fan-shaped appearance, rounded off like a normal finger. The length was exactly the same as her ring finger. The nail, of course, while only half-length, made an inconspicuous deformity.

I have seen several of Dr. Jones' patients on whom he had performed this operation and the results obtained were indeed splendid. I am inclined to believe that in most instances I would prefer his method to the one I used. His success is due to his careful and meticulous attention to every detail.

CARLETON MATHEWSON, JR. (San Francisco, Calif.): I feel unqualified to discuss this paper, because I have not had an opportunity to use the operation Dr. Jones describes. I have had the opportunity, however, of seeing one of Dr. Jones' patients, a typist who had an excellent functional and cosmetic result.

There are a few minor points which I think are important. Dr. Jones suggest the use of local block anesthesia in carrying out the operation. I might say that if you do use local anesthesia for blocking off the finger, you should avoid the use of adrenalin. We have seen gangrene of the tip of the finger which we attributed to interference in circulation caused by the use of adrenalin and novocaine. I think one cannot overemphasize the importance of thorough cleansing of the hand. We have found it very difficult to cleanse the hand thoroughly in any acute injury. Most of these injuries occur to people who, because of the type of their employment, have extremely greasy or dirty hands. I have watched nurses attempting to hold an extremity with one hand and clean it with the other. The results are not efficient, so that in the end one is dependent upon antiseptics rather than thorough cleansing for asepsis.

It has been my habit in these small injuries of the hand to block off the finger with local anesthesia, then to take the patient into the scrub room with me and show him how to scrub up for an operation, instructing him to scrub his hands at the same time. He rather enjoys it and you get the hand thoroughly cleansed.

Many patients think that we can perform miracles, which is often fortunate in this type of injury. Very often persons who have lost a portion of a finger or the whole finger, bring it in in a handkerchief. They usually pick up the abolated part, place it in a handkerchief, then run for the emergency hospital. If they do bring in the tip of the finger, very often you can cleanse it and suture it in place. Occasionally, it will take as a free graft and will give you a good functional result.

We have also found it useful in acute injuries that are still bloody to cleanse an area of skin on the forearm and then place the bloody tip of the finger on this area. In this manner one can outline accurately the size of a full thickness graft.

THE TREATMENT OF FRACTURED PATELLA BY EXCISION*

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THE patella has been a bone of contention for a great many years. Because of its superficial location and the frequency of its fracture and refracture, it has always attracted considerable attention. In the treatment of fracture of this small bone, the great variety and number of methods in use throughout the nineteenth century give evidence of the unsatisfactory results commonly obtained. This was particularly true following conservative or nonoperative treatment, but also true to a lesser degree following open reduction.

It is the purpose of this presentation to endorse and advocate a newer and more satisfactory method of treatment and to present evidence of its success as applied in a relatively small recent series of cases.

HISTORICAL

Up to 1870, fracture of this bone was with few exceptions treated conservatively by splinting the affected extremity in extension, by bedrest, elevation of the leg and massage. Convalescence was prolonged, bony union rare, and except for isolated instances the end results were far from satisfactory. Permanent disability in varying degrees was expected and more or less assured. In view of this fact and in an effort to get closer or bony union with resultant improved functional results, some of the more venturesome surgeons resorted to treatment by means of Malgaigne's hooks, Robson's and Anderson's pins, subcutaneous and pericutaneous suture and innumberable other methods which, though carrying greater risk and danger to the patient, showed little improvement in the end results.

ARTHROTOMY WITH OSSEOUS SUTURE

In March, 1877, Sir Hector Cameron of Glasgow, Scotland, and in October of the same year, Lord Lister[1] treated patients with a fractured patella by opening the knee joint and wiring together the

exposed fragments of the patella. This procedure, soon called "Lister's great experiment"[2] attracted the attention of the surgeons throughout the world.

Five years later, in 1883, Lord Lister presented seven cases to the London Clinical Society in which cure was obtained and staunchly advocated and argued for the procedure. For several years, however, this operation met with more or less universal scorn, ridicule and condemnation.

Objections and criticisms to it naturally centered around the risks and dangers associated with arthrotomy. In those early days of antiseptic surgery, suppuration, sepsis, ankylosis, amputation and death too frequently followed opening and exposing the largest synovial cavity in the body.

Dennis,[3] in 1885, in the course of investigating the history of wiring the patella was able to collect forty-nine cases performed previous to 1883 and from the literature and elsewhere collected 137 cases performed in the years 1883 to 1885. From this study and his own personal experience in the treatment of fractured patella by both open and closed methods, he concluded that the older methods were, in general, unsatisfactory. He agreed with Lister and likewise considered arthrotomy with metallic suture the ideal method of treatment at that time.

During the next few years this operation was performed with increasing frequency and ample evidence was soon accumulated to show beyond question of a doubt, that convalescence and restoration of function was more rapid and complete and that bony union was the rule rather than the exception following this new operation.

Stimson,[4] in 1898, citing his considerable personal experience,* stated, " . . . Resort to a method which involves risk to life or such disability as is produced by ankylosis or amputation, can be justified only when that risk is very small." He agreed that with open operation the period of convalescence and rehabilitation was much less and a good result more certain but added that when failures occurred, they were often disastrous. In his series of seventy consecutive cases 1892 to 1898 in which open incision was employed, close union and recovery without mishap occurred in all cases.

When one considers the remarks of Dennis as well as Bull[5] relative to the usual convalescence and end result following the older

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* His experience comprised subcutaneous mediate silk suture through the tendon and ligamentum patellae, about forty cases 1889 to 1892 and open incision with the same or fibroperiosteal suture, about seventy cases 1892 to 1898.

methods of treatment of fractured patella, he can appreciate how and why the newer method, once established, was received with universal acclaim. Dennis in a long list of objections to the older methods of treatment mentioned, " . . . partial and complete ankylosis, pain in the joint, the necessity for crutches often for two years, the wearing of a knee cap, the use of a posterior splint for life, the strong probability of refracture, the sense of insecurity in standing, the constant fear of falling, the inability to walk with any certainty, the muscular atrophy of the limb, the tedious and long convalescence and many other conditions too numerous to mention and too familiar to all."

By 1900, the open operation had become quite popular, for with the development of antiseptic and later aseptic surgery, the chief obstacle—infection—was rapidly overcome. Many of the prominent surgeons of this country and abroad were using this method and advocating its general adoption. Powers,[6] in 1898, collected and cited the experience of some seventy-one American surgeons who treated 679 patients with fractured patellas by open arthrotomy with no amputations and only three deaths. Satisfactory results were reported in 94 per cent of these cases. He concluded from his investigation, that this procedure had at that time a well fixed place in surgery and had received the endorsement of the majority of the prominent American surgeons.

Heineck,[7] in 1909, analyzed 1,100 cases of fractured patella treated by the open operative method during the previous ten years and concluded from the available statistics that the risk from open arthrotomy in skillful and careful hands was practically nil. He, too, considered the open operation as the method of choice.

Three types of operation were at that time most popular. All included arthrotomy as the first step; all included careful repair of the soft parts as an essential step. They were: (1) osseous suture, (2) cerclage, (3) "suture des ailerons."* Excellent functional and anatomical results were obtained with each of these methods and it is interesting to observe that most of the advocates of osseous suture emphasized early the importance of repairing the lateral and medial tendinous expansions of the quadriceps tendon.

Since 1910, open reduction has been generally accepted and taught as the operation of choice in the treatment of transverse frac-

* Peyrot said, "In fractured patellae, absolutely perfect results from the standpoint of contour, solidity and function have been obtained in a relatively short period in cases in which all suturing was limited to praepatellar and parapatellar tissues."

ture of the patella with separation of fragments. Many and varied ways of holding the fragments together have been described and used, some quite ingenious, all claiming some merit. All types of suture material have been used including wire of all kinds, gut, tendon, fascia, linen, silk, etc. Nails, screws, Lane plates and even inlay grafts also have their advocates who at times have claimed much for their particular choice; but regardless of the method advocated or used, all strove to secure bony union with relatively prompt and complete recovery of function.

That bony union occurred more frequently following open operation, there can be no doubt, but that there were numerous failures to obtain such union is equally unquestionable. Results were obviously better but some of the objections and complications attributed to the older methods of treatment evidently continued to exist with the new.

In 1910, Corner,⁵ of London, published some interesting figures about fracture and refracture of the patella as seen at St. Thomas' Hospital. His statistics relate to those cases admitted between 1890 to 1907 inclusive, some 504 in number. Some of these statistics seem relevant for which reason a few are listed. Transverse fractures were the most frequent, comprising 85 per cent, comminuted fractures were next most frequent, comprising 10 per cent. Compound fractures were seen in only 1 per cent of cases. Two patients underwent operation for every one which did not. The patella was sutured in 65 per cent of cases. Splints and massage were used in 35 per cent of cases. The patella was the most frequently refractured bone in the body.

The percentage of refractures was approximately the same after either operative or nonoperative treatment,* 10 per cent in the case of suture of the fragments, 9 per cent after other treatment. The information furnished by these statistics of Corner is significant even though disappointing, for one of the chief advantages claimed for the open operation seems to have been established not so well as was thought. If other and later reports show similar figures relative to refracture, one would be obliged to assume that the advantages of open suture of the fragments are solely in the relatively complete and quick recovery of function in the limb.

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* It was observed that after suture 69 per cent of refractures occurred within the first year and 88 per cent within the first three years. In patients receiving treatment, other than suture, 14 per cent of refractures occurred within the first year and 86 per cent after the first year.

The wave of enthusiasm for open reduction during the years 1885 to 1910, though slow in getting started, had by this time (1910) swept all obstacles and criticism aside and the operation now received general commendation. The advantages claimed seemed to have been substantiated by experience: (1) Great risk to life and limb had been eliminated. (2) The fact that bony union could be obtained was established. (3) Repair was more rapid with the open operation. (4) Results were superior as regards function of limb and knee joint.

Arthrotomy with safety, bony union, rapid repair and good function sum up in a few words the contribution of Lord Lister and his followers to the treatment of patellar fractures.

END RESULTS FOLLOWING OSSEOUS SUTURE

Powers, nevertheless, in his very thorough investigation as to the question of operative interference, was not completely satisfied with the results reported and very aptly expresses what we believe is still true today, " . . . But in the matter of ultimate results our conclusions must be in large part inferential, as with but few exceptions the cases have been reported too soon after operation. They are instances of operative recovery, and they permit an expression of the individual opinions of the reporters, but they unfortunately do not warrant judgment as to the definite usefulness of the limb after the lapse of a suitable length of time . . . The cases should be thoroughly tested after a lapse of one or two years, for in no class of fractures does time make greater changes . . . Tests should be made systematically and should be both structural and functional . . . The truest test as to result is the ability to walk long distances, to pursue arduous occupations, to easily ascend and descend stairs and the like . . . But very few of the reported cases bear this examination."

We have in our limited experience seen quite a few patients of others as well as our own, who, after a period of from one to fifteen years following open reduction for fractured patella, still have considerable loss in knee joint function (usually limitation in flexion) although the limb must be considered a very useful one. We must also admit that after investigation and from our own observations, the usual postoperative treatment and convalescence following open reduction still occupies a considerable period of time, comprising in many instances four to six weeks' hospitalization and as many months before the patient is able to return to any arduous work. This relatively prolonged period of disability is no doubt the result

of overconservatism displayed in an effort to prevent refracture and it is quite probable that splinting and immobilization has in the past been unnecessarily prolonged.

EXCISION OF THE PATELLA PARTIAL AND COMPLETE

Notwithstanding the markedly improved results which followed the treatment of fractured patella by open reduction and osseous suture, much was left to be desired and there is still considerable room for improvement. It is not surprising therefore that partial and complete excision rather than repair of the fractured patella was next considered, suggested and performed.

Chaput,[9] in the description of his several methods of treating fractured patella in 1891, discussed the treatment of old fractures and called attention to a type wherein the superior fragment impaired flexion. In this type he performed with good result and recommended extirpation of the offending superior fragment. In another type* in which the patella was too long and interfered with flexion because of its excessive length and breadth, he advised complete extirpation and stated that the operation was easy and was not followed by any functional disturbance.

Stimson, in 1898, discussing the treatment of old fractures of the patella resulting in diminution of function stated, "It is known that partial or total loss of the patella does not involve loss of function; the quadriceps retains control of the leg through its fibrous and fascial connections . . . "

Heineck, in the analysis previously referred to, comprising 1,100 cases, was able to find in the literature thirteen cases in which the removal of the patella constituted the sole operative procedure on the knee joint. Of these, five were for fractures, four for tuberculosis, three for chronic osteomyelitis and one for malignancy. From the study of these as well as cases of congenital absence, he concluded that a deficiency or absence of the patella was invariably associated with an impairment in function and power. His strong and definite feeling in this matter is quoted, "In uncomplicated transverse fractures of the knee cap, the extirpation of the patella as a form of treatment is to be condemned. In comminuted fractures it deserves consideration only as a measure of last resort."

It would seem that the few cases at that time available for study scarcely justified the attitude assumed and so strongly expressed,

* "Old fractures of the patella with a rigid callus with elongated patella and impaired flexion should be treated by complete extirpation of the patella." (Chaput.)

relative to the indispensability of the patella and the functional impairment resulting from its loss. It would seem more than likely that the impairment in function was the result of associated damage, disease or neglect to the soft parts and not to the absence of the patella. His dogmatic statement to the effect that a knee joint without a patella is an impaired joint, seems to have been made upon inadequate evidence, notwithstanding the fact that included in the cases he was able to collect and publish from the literature, were three belonging to Mr. W. Morey Willis[10] who on December 4, 1907, reported before the Nottingham Medico-Chirurgical Society these three cases in which he had completely excised the patella for fracture. At that time he demonstrated his last case which had been operated upon five months previously. The movements of the joint were perfect and he reported that the results in the other two cases were also excellent. In all three cases he regarded the result as equal if not superior to that obtained by wire suture. In this same collection of cases by Heineck was also included a case of Dr. Charles L. Scudder.[11] This patient suffered marked comminution of both patellae and after complete excision of both, was reported to have excellent functional use of both knees. There are, undoubtedly, many other cases either unreported or not found in the earlier literature which, like the cases of Willis and Scudder, would lend additional evidence tending to invalidate the deductions of Heineck.

Thomsen,[12] in 1934, recommended partial excision of the patella in cases of fresh fracture showing comminution in which there were one large fragment and several small fragments. He believed that by excising the several smaller fragments, only union of tendinous structures was involved and success assured. He reported that the results obtained in his five cases were uniformly satisfactory.

Blodgett and Fairchild,[13] of the Receiving Hospital in Detroit, Michigan, reported their experience with partial and total excision of the patella for acute fracture. At that institution during the years 1932 to 1934 inclusive, fifty-five cases required open reduction, thirty-five of these patients were treated by various suturing processes and twenty were treated by partial or total excision of the patellar fragments. The end results in both groups are interesting in that few such statistics have been published. From them one ascertains that the end results following osseous suture were far from satisfactory and partial or complete excision of the patella has some merit. The reported end results follow:

"Of the 35 cases repaired by various suturing processes, in twenty the results were unknown. Only fifteen cases could be examined and appraised from seven to thirty-six months postoperative. Of these:

> 7 classified excellent   . Limb and knee joint useful as before
> 3 classified good....... Improving, nearly full flexion, moderate difficulty
>   in getting up and down stairs.
> 5 classified fair........ Fair economic usefulness, function often con-
>   siderably diminished.

"Of the twelve cases treated by partial excision, in five the results were unknown. Only seven could be examined from six to twenty-six months postoperative. Of these, six were rated as excellent and one good.

"Of the eight cases treated by complete excision, in four the results were unknown, one was rated as excellent and three were rated good."

It is worthy of note that in the above series of cases the results following osseous suture were far from satisfactory, less than 50 per cent of the followed cases showing a limb or knee joint as useful as before the accident. It is unfortunate that end results were obtainable in only 50 per cent of the excision cases. From this small group of cases (eleven cases) and as particularly shown in the complete excision group, the superior end results following excision were not convincingly demonstrated. The authors (Blodgett and Fairchild) were never the less convinced that partial and total excisions of the patella were productive of excellent results. They believed that many disadvantages encountered in osseous repair such as, inaccurate reposition of the posterior articular surfaces of the fragments, subsequent adhesions to the femur and in some cases the necessity of removing wire suture material were eliminated by excision. They also observed that convalescence and rehabilitation were considerably shortened. If there was a sizable lower fragment, they recommended excision of the upper fragment or fragments. In cases of marked comminution with wide separation and in those in which there was no sizable lower fragment they recommended total resection.

In April, 1937, R. Brooke,[14] of England, reported thirty cases in which the patella had been completely excised during the seven years previous to publication. From his personal experience he was impressed " . . . with the rapid and smooth recovery and the relatively very complete recovery of function permitting laboring men to

return to their work within a month or six weeks of the operation." His presentation though startling, was convincing. His conclusion, short and precise follows, "The patella is an integral part of the skeleton phylogenically inherited, and function plays no part either in its formation or its growth. In man it subserves no important function. It is a morphological remnant which is tending to undergo reduction and to disappear. It has become modified to take part in movements of the knee joint, but its presence is incidental and is a deterrent rather than an aid to these movements. Experimental and other evidence has been advanced to show in its absence the efficiency of the knee joint is, if anything, increased both as regards the rapidity of movement and power." Such a statement is to the average person difficult to believe and quite provocative.

Groves,[15] of Bristol, editor of the *British Journal of Surgery*, admitted that he, too, was quite skeptical when he heard of Mr. Brooke's claims and requested to see some of the results. Mr. Brooke showed him eight cases after which Groves admitted that the claims were fully justified stating, that when the knees were covered it was impossible in any case to identify the injured limb or detect any difference in function. "Convinced but still mystified as to how the mechanism of the extension of the knee could be so perfectly carried out in the absence of the patella, I sought the help of Professor Whitnall of Bristol University, Anatomical Department." Together, after studying anatomical preparations they were convinced that it was the suture of the lateral tendinous expansions of the quadriceps tendon which was most important and concluded that by removing the fragments a better repair could be obtained.

Since the report of Brooke, Tippett[16] reported in 1938 the results in four excision cases, Mehriz,[17] in 1939, the result of a single case and Dodd,[18] in 1939, enthusiastically endorsed the procedure reporting excellent results in five cases.

THE PRESENT SERIES OF CASES

The article by Brooke, of England, previously referred to, brought to our attention this new and startling method of treating fractures of the patella. The advantages claimed were so convincingly demonstrated in photographs that we decided to give the procedure a trial.

We have since November, 1937, on the Fracture Service at the E. J. Meyer Memorial Hospital, treated all patients with a fractured patella with comminution and separation of fragments by complete

excision. In other words, any case requiring open operation was treated by complete excision of the fragments.

Our experience during the past three and one-half years comprises twenty-one cases. Twelve service patients and one private patient were operated upon by the authors. Eight private patients were operated upon by five other local surgeons. With one exception the results obtained have been most satisfactory and gratifying. Table I shows the distribution of cases over forty-one consecutive months. It is interesting to observe that the first private patient was treated by excision only after impressive experience and end results had been observed in five service patients operated upon during the preceding twenty-two months. In summary, Table II supplies the following data:

Age Incidence. The oldest patient was a woman of seventy-nine years, the youngest a boy of eighteen years. The average age for the entire group was fifty-two years.

TABLE I

ANALYSIS TWENTY-ONE EXCISION CASES ACCORDING TO CASE STATUS AND DISTRIBUTION OVER YEARS

Nov. 1937 to Mar. 1941	Service Cases	Private Cases	Total Cases
1937	2	0	2
1938	2	0	2
1939	1	1	2
1940	5	6	11
1941	2	2	4
Total	12	9	21

Sex. There were fourteen males and seven females; ratio 2:1.

Right and Left Patella. The right patella was fractured in eleven cases, the left in ten cases. In only one instance were both patellae fractured, only the left requiring operation because of marked comminution and wide separation of fragments (Case 11).

Complicating Factors. The fractures were simple in all but one instance (Case 6) which was compounded. Two of the cases (3 and 13) were refractures, in each instance the same patella having been fractured and sutured on two previous occasions. Two cases (11 and 17) had associated injuries which either delayed convalescence or complicated the end result. The patient in Case 11 sustained fractures of both right and left patellae. The right, though comminuted,

TABLE 11

PATELLAS EXCISED FOR FRACTURE

(Twenty-one cases in forty-one months)

Case No.	Private or Service	Case Initials	Sex	Age	Patella	Date Injured	Date Operated	Interval between Injury and Operation	Injuries Complicating	Hosp. Days P.O.	Time since Oper.	End Result
1.	Service	P. F.	M	53	left	11/6/37	11/6/37	24 hours	none	40	41 mo.	Excellent
2.	Service	J. Y.	M	71	right	11/30/37	12/14/37	14 days	none	41	40 mo.	Excellent
3.	Service	W. B.	M	62	left	3/25/38	3/30/38	5 days	3rd. time fractured	18	36 mo.	Excellent
4.	Service	M. G.	M	18	left	5/25/38	5/26/38	24 hours	none	21	34 mo.	Excellent
5.	Service	H. A.	M	41	right	5/6/39	5/6/39	24 hours	none	27	22 mo.	Excellent
6.	Private[20]	E. J.	M	27	right	8/31/39	8/31/39	24 hours	fractured humerus	18	19 mo.	Excellent
7.	Private[21]	C. C.	M	54	right	12/22/39	1/8/40	17 days	none	16	14 mo.	Excellent
8.	Service	E. N.	M	41	left	2/15/40	2/17/40	2 days	none	21	13 mo.	Excellent
9.	Service	S. G.	M	57	left	3/23/40	3/25/40	2 days	none	21	12 mo.	Excellent
10.	Private[22]	P. A.	M	60	left	6/8/40	6/11/40	3 days	none	21	9 mo.	Excellent
11.	Private	E. S.	M	33	left	7/5/40	7/9/40	4 days	fracture both patellae	42	7th week	Died
12.	Private[21]	M. J.	F	50	left	10/7/40	10/15/40	8 days	none	21	5 mo.	Excellent
13.	Private[23]	F. S.	F	53	left	11/1/40	11/8/40	7 days	3rd. time fractured	16	4 mo.	Excellent
14.	Private[24]	J. L.	F	53	right	11/4/40	11/12/40	8 days	none	27	4 mo.	Excellent
15.	Service	L. P.	F	42	right	11/21/40	11/23/40	2 days	none	21	4 mo.	Excellent
16.	Service	J. B.	M	51	left	11/15/40	11/26/40	11 days	none	21	4 mo.	?
17.	Service	I. P.	F	54	right	11/30/40	12/4/40	4 days	fracture opposite ankle	42	3 mo.	?
18.	Service	H. S.	F	79	right	1/8/41	1/16/41	8 days	none	40	2 mo.	Excellent
19.	Private[23]	G. B.	M	55	right	1/20/41	1/24/41	4 days	none	9	2 mo.	Excellent
20.	Private[20]	J. W.	F	72	right	2/2/41	2/2/41	24 hours	none	12	2 mo.	?
21.	Service	P. N.	M	58	right	11/29/40	3/17/41	107 days	none	21	1 mo.	?

From our small and limited experience the patients without complications are, with rare exceptions, walking well without dressings, aid or discomfort at the end of the second week; and as no physiotherapy other than active use is prescribed, there is no reason for keeping them in the hospital for any appreciably longer period of time. As shown in Table III, the average postoperative period of hospitalization for the eight private cases was two and one-half weeks.

Interval between Injury and Operation. The time elapsed between fracture and excision varied considerably. (Table IV.) In general, each patient was operated upon as soon after admission as seemed practical. The preoperative condition and preparation of the patient as well as reasonable convenience, were all taken into consideration. It is our impression that delay offers no advantages. Provided that there are no gross contraindications to immediate arthrotomy or any valid reasons for delay, immediate operation is advised.

Our experience in this series, excluding the most recent patient (Case 21) who first consulted a physician three and one-half months after injury, shows that the average time interval between injury and operation amounted to 5.5 days.

5 patients or 24 per cent were operated upon within twenty-four hours or less.

8 patients or 38 per cent were operated upon within forty-eight hours.

12 patients or 57 per cent were operated upon within four days.

9 or 75 per cent of the service patients were operated upon within five days of injury.

TABLE IV

TIME ELAPSED BETWEEN INJURY AND OPERATION

(Twenty-one cases)

Interval between injury and Operation	Case Numbers
24 hours or less	1, 4, 5, 6, 20—24% operated upon 24 hours or less
2 days	8, 9, 15 —38% operated upon within 48 hours
3 days	10
4 days	11, 17, 19 —57% operated upon within 4 days
5 days	3
7 days	13
8 days	12, 14, 18
11 days	16
14 days	2
17 days	7
	————————20 cases. Average 5.5 day interval between injury and operation.
107 days	21

The average time interval would have been considerably less had all of the cases entered the hospital immediately after injury.

It should be recalled that the quadriceps femoris muscle, powerful extensor of the leg, consists of four different heads viz., the rectus

FIG. 1. Fresh cadaver specimen showing normal relation of patella to quadriceps tendon. A, viewed from the front showing quadriceps tendon, the lateral and medial tendinous expansions, the patella and patellar ligament. B, same as (A) viewed from behind, showing articular surfaces of the same structures. Observe that the posterior surface of the tendon is attached to the anterior surface of the patella. C, same as (B) showing the patella detached from the posterior surface of the tendon and reflected proximally. Note the relatively small patellar defect in the tendon and the strong tendinous lateral and medial expansions.

femoris, vastus medialis, vastus lateralis and vastus intermedius, all of which converge and unite to form the quadriceps tendon. This broad, common tendon of insertion passes over the patella to become continuous with the patella ligament which is inserted into the tuberosity of the tibia. The quadriceps tendon, in addition to being firmly attached to the anterior surface and lateral margins of the patella, furnishes tendinous lateral and medial expansions which pass downward to be inserted into the margins of the lateral and medial condyles of the tibia, respectively. The superior and inferior articular margins of the patella are covered with fat and there are no ligamentous fibers attached thereto.

Because of its relation and attachment to the quadriceps tendon, the patella can be readily dissected free from the posterior surface of the tendon. This is well demonstrated in Figures 1A, B, C and D which are photographs of a specimen taken from a fresh cadaver. From them, one can readily understand why removal of the patella

Fig. 1D. Longitudinal section of
the same specimen, showing ten-
don from which the normal pa-
tella has been excised. (See Fig.
19C).

does not interfere with subsequent function, there being no appreciable loss in tendon continuity provided the lateral and medial tendinous expansions are well repaired.

THE OPERATION

Indications. Any simple fracture of the patella with separation of fragments which requires open operation and all compound fractures require operation.

Preoperative Preparation. From the time of injury to operation, the injured extremity is elevated and splinted comfortably in extension. In view of the fact that early operation is contemplated and usually performed, little or no benefit is to be expected from pressure bandages, hot or cold applications, etc., and they are therefore not used. Careful preoperative examination and study of the patient is of course carried out the same for this as any other operation. Preoperative treatment and sedation naturally varies with the surgeon and the type of anesthesia to be used. Low spinal anesthesia was found to be very satisfactory and was used in most, though not all of the cases of this series.

The field of operation is prepared according to the custom and desire of the operating surgeon. The authors scrub the entire extremity from groin to ankle thoroughly with ether. Tincture of iodine is then applied over the same area and after it has dried it is removed with alcohol. The operative field is then draped so as to expose the knee generously.

Incision. Either a transverse or vertical incision, six to eight inches long, centered over the patellar fragments will give adequate exposure permitting excision of the fragments and repair by suture of the tendon and tendinous expansions. (Fig. 2A.)

The incision divides skin and fascia immediately exposing the line of fracture and the contused, lacerated soft tissues. Considerable and varying amounts of blood, bloodclot and synovial fluid escape from the knee joint. Retraction of the wound edges reveals the extent of the lacerations of the lateral and medial tendinous expansions, which is usually extensive. (Fig. 2B.)

Excision of Patellar Fragments. The number of fragments depends upon the extent of comminution. Commonly, there are one large proximal and several smaller distal fragments. The rents in the lateral and medial tendinous expansions of the quadriceps tendon make it possible to evert or turn out these fragments. This step is facilitated by the use of a towel clip, which permits firm traction and

eversion of the fragment away from the fracture line. (Fig. 2C.) By sharp dissection and at the same time closely hugging the anterior surfaces of the patellar fragments, they are removed with special care to preserve intact the overlying tendon.
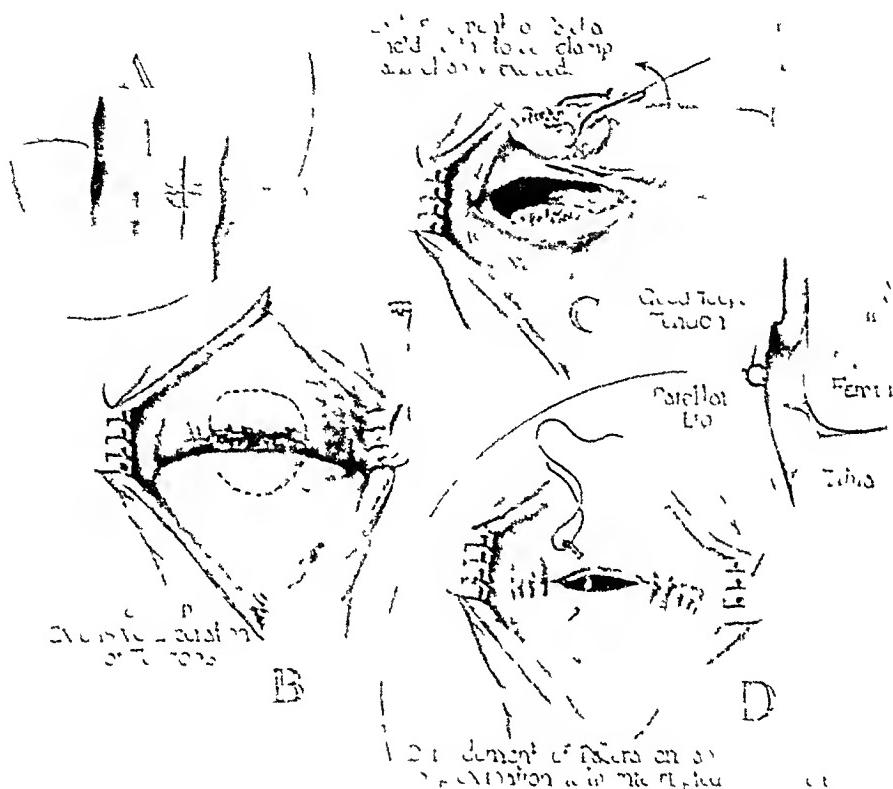
Fig. 2. Steps in the operation for excision of the patella.

Repair of Tendon and Lateral Tendinous Expansions. After the fragments have been completely excised, the contused and hemorrhagic, frayed, adjacent edges of the tendon and tendinous expansions are sparingly débrided and repair is completed by approximating the freshened edges with interrupted sutures. Any hemorrhage encountered should be accurately controlled by ligature and special care is exercised to see that the tendinous expansions are sutured well laterally and medially without tension. It is advantageous to suture the lateral and medial tendinous expansions first for by so doing, the much thinner, central portion of the tendon, originally attached to the patella, is approximated with greater ease and less tension. (Fig. 2D.)

Closure of Wound.   The wound is closed in two layers, fascia and skin, by interrupted, continuous or subcutaneous suture depending upon the type of suture material used. A sterile, snug pressure bandage is applied. No splinting of any type is necessary or used.

Suture Material.   In this series of twenty-one cases, various kinds of suture material were used, there being a marked preference shown for silk.

> No. 10 black silk was used in 10 cases (5, 6, 8, 9, 11, 15, 17, 18, 20, 21)
> Chromic catgut was used in 6 cases (1, 4, 7, 10, 12, 14)
> Fascia lata   was used in 2 cases (2 and 3)
> Alloy wire   was used in 2 cases (13 and 19)
> Chromic and silk were used in 1 case (16)

Of the thirteen patients operated upon by the authors, silk was used in eight, fascia lata in two, chromic gut in two and silk and chromic gut in one. From the observation of the convalescence in this small group of cases, it would appear that the type of suture material used was immaterial. It seems logical, therefore, to recommend that suture material least apt to cause tissue reaction be used.

POSTOPERATIVE CARE AND REHABILITATION

The operative wound having been closed and dressed, several layers of sheet wadding are applied over the sterile protective dressing and the entire knee is snugly bandaged with a five-yard flannel bandage.

The patient is at once permitted and encouraged to move freely about in bed and there is relatively little discomfort which is controlled with mild sedatives.

On the third or fourth day, he is allowed out of bed and encouraged to walk about, with or without the aid of a cane, according to the desires of the patient. This step is, as a rule readily accomplished with great surprise and satisfaction to the patient. Upon realizing that he is able to walk with little or no discomfort and only a slight limp, he is more than willing to follow enthusiastically the active exercises outlined and prescribed. Progress is amazingly rapid from this stage. During the first week, the snug flannel bandage is left undisturbed. In addition to compressing and protecting the operative site, any marked degree of flexion is prevented and the sense of support and security afforded by its presence inspires confidence.

Between the seventh and tenth days, the wound is dressed for the first time. The stitches are removed, all dressings discarded and active flexion and extension exercises are instituted. By the end of
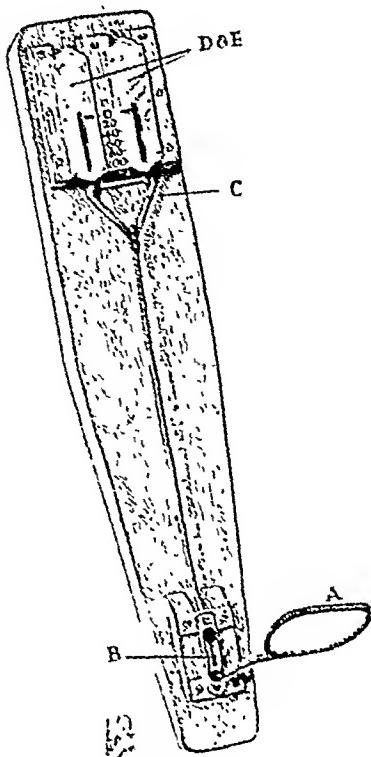
FIG. 3. Dynamometer for meas-
uring quadriceps extensor fe-
moris muscle power. The
patient places the heel of the
shoe on the limb to be tested
in cable loop (A). The attached
cable extends around pulley
(B) and passes upward to arm
(C) connecting two parallel
fifty-pound spring scales (D
and E) which are firmly
mounted on a stout board. The
instrument is held between the
legs of the patient. In a sitting
position, both buttocks placed
squarely and well back on a
suitable chair or table top,
quadriceps extension power is
recorded in pounds o to 100.
See photographs of dynamom-
eter in use. (Figs. 4D, 5D and
8D.)

the second week complete extension and 90 degrees flexion have usually been obtained and the patient gets around actively and comfortably without aid of any sort. It is quite impressive to see these patients at this stage, walking about the wards and hospital corridors as well or better than many of their fellow convalescent patients who had no injury or operation.

The patient is discharged from the hospital at this time with instructions relative to the active use of the operated extremity. He is encouraged to do a considerable, increasing amount of walking daily and is instructed to walk up and down stairs whenever and as much as possible. To negotiate stairs is the most difficult part of rehabilitation and this important criterion of function is the last obtained.

With progressively increasing active use, the patient is, at the end of six to eight weeks able to be on his feet all day, walk long distances and negotiate stairs. In many instances he is able to return to laborious work including climbing between the second and third month.

Full and complete function is demonstrable in some earlier than in others depending upon the amount of stoicism and co-operation displayed. Compensation and lawsuits will exert their influence unfavorably of course, but generally speaking from the end results obtained in this series there is no functional impairment at the end of four months.

END RESULTS

The end results in this series of cases were critically evaluated by more than one observer and because of the unbelievable excellent result almost invariably obtained, many of the cases have been shown to the sceptics on numerous occasions. The result as here recorded was considered excellent only when the function of the limb and knee joint was observed to be normal in all respects. Such classification required: (1) Powerful and complete extension of the injured leg equal to that of the uninjured extremity; (2) complete flexion of the leg on the thigh, equal to that of the uninjured extremity; (3) the ability to kneel and rise from kneeling position without discomfort; (4) the ability to bear the body weight on the semiflexed injured extremity alone; (5) the ability to walk long distances comfortably, normally and without a limp; (6) the ability to negotiate stairs normally and comfortably; (7) the feeling of stability and security in the injured extremity; (8) complete lack of subjective complaints

suggesting disability or inferiority as compared to the uninjured extremity; and (9) in those cases in which pre-existing disability made it impossible to fulfill the preceding requirements, the result


Fig. 4. Case I. Laboror, age fifty-three, photographed thirty-six months postoperatively. Left patella excised November 6, 1937. A, full function six weeks. It is difficult to identify the affected knee. B, kneeling and full flexion demonstrated. C, body weight easily supported on semiflexed affected limb. D, extension power unaffected limb forty-two pounds. E, extension power affected limb fifty pounds.

was considered excellent when the function obtained was said to be equal or better to that present immediately prior to the patella injury. (Cases 3 and 13.)
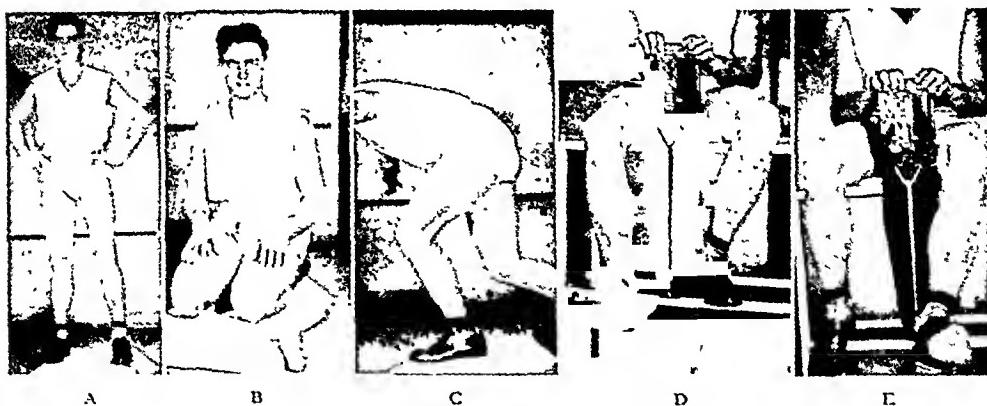
Fig. 5. Case IV. Laboror, age eighteen, photographed thirty months postoperatively. Left patella excised May 26, 1938. A, full function three months. It is difficult to identify the affected knee. B, kneeling and full flexion demonstrated. C, body weight easily supported on semiflexed affected limb. D, extension power unaffected limb sixty pounds. E, extension power affected limb sixty-four pounds.

Such an evaluation as described is indeed critical and demanding but, nevertheless, essential to substantiate the extravagant claims of those advocating the procedure of excision of the patella for fracture. Very few cases of fractured patella, regardless of the method by

which they were treated, have been analyzed so critically as far as end results are concerned.

Of the twenty-one cases in this series, one (Case 11) patient died

A   B   C   D

FIG. 6. Case 1. Dining car waiter, age forty-one, photographed eighteen months postoperatively. Right patella excised May 6, 1939. Full function six weeks. A, it is difficult to identify the affected knee. B, kneeling and full flexion demonstrated. C, squatting and full flexion. D, body weight easily supported on semiflexed affected limb.

in the seventh postoperative week, the result of pulmonary embolism. Progress up to the time of death promised an excellent result.

Of the twenty patients surviving the operation, in two instances (Cases 20 and 21) not sufficient time had elapsed when last examined to expect or warrant the recording of complete return of function.

Two of the remaining eighteen patients (Cases 16 and 17) failed to respond or report for end result check up in time for this report, though our latest out-patient follow-up records showed them to be progressing satisfactorily.

In sixteen cases we were able to demonstrate an excellent result from three to forty-one months postoperatively without exception or exaggeration. All of them have returned to their usual work as laborers or housewives.

Photographs of the end results in several of the cases of this series are submitted to demonstrate the completeness of functional return. (Figs. 4, 5, 6, 7, 8, 9 and 10.)

DYNAMOMETER TEST FOR QUADRICEPS POWER

A dynamometer for measuring the power of the quadriceps femoris muscle was improvised by the senior author. It is quite simple in construction and operation. (Fig. 3.) For purposes of

comparison and progress determination, it has proved quite valuable as a means to portray visually and record the power of extension in pounds.

FIG. 7. Case VIII. Laboror, age forty-two, photographed nine months postoperatively. Left patella excised February 17, 1940. A, it is difficult to identify the affected knee. B, kneeling and full flexion demonstrated. C, body weight easily supported on semiflexed affected knee.

In those cases tested it has been constantly observed that the power of extension is unimpaired following the complete removal of the patella and strange as it may seem, in many of the cases power is from three to eight pounds greater in the limb from which the patella has been excised than in the unaffected extremity.

REGENERATION OF THE PATELLA

Blodgett and Fairchild stated, "The patella does not regenerate following excision." This statement of fact seems to have been based on a single case which showed no radiographic evidence of regeneration six months after excision.

Brooke, in reciting his larger experience, did not touch on the subject of regeneration.

Carey,[19] Zeit and McGrath, however, in their studies in the dynamics of histogenesis with particular reference to the regeneration of the patellae of dogs, presented experimental evidence to support the following findings:

"Under adequate mechanical conditions produced by an intact, normally mobile knee joint and its related soft parts, patellar cartilage and bone regenerate after the patella is excised, from young

connective tissue cells which had not been destined as specific formers of bone.

"When adequate mechanical conditions are altered by means of

A   B   C   D   E

FIG. 8. Case IX. Laboror, age fifty-seven, photographed eight months postoperatively. Left patella excised March 25, 1940. Full function ten weeks. A, it is difficult to identify the affected knee. B, kneeling and full flexion demonstrated. C, body weight easily supported on semiflexed affected limb. D, extension power unaffected limb fifty pounds. E, extension power affected limb 50 pounds.

A   B   C

FIG. 9. Case XIV. Housewife, age fifty-three, photographed three months postoperatively. Right patella excised November 12, 1940. A, except for transverse incision, one could not identify the affected knee. B, lateral view demonstrating complete extension. C, complete flexion demonstrated.

immobilizing the knee joint (arthrodesis), with the patella left intact, patellar cartilage and bone atrophy.

"When the patella is excised in toto and adequate mechanical conditions are altered by means of knee joint fixation, patellar cartilage and bone do not regenerate, even with the tendon of the

quadriceps extensor femoris muscle and the patellar ligament united by suture.

"The *adequate mechanical conditions* are a normally mobile,

FIG. 10. Case XVIII. Elderly woman, age seventy-nine, photographed three months postoperatively. Right patella excised January 16, 1941. A, except for scar, it is difficult to identify the affected knee. B, lateral view demonstrating complete extension. C, full flexion demonstrated.


FIG. 11. Case I. Regeneration of the patella? (Thirty-six months.) A, preoperative x-ray left knee. B, same knee one month postoperatively. Notice early patellar regeneration. C, same knee thirty-six months postoperatively. Notice evidence of progressive regeneration. (Areas of bone larger and more dense.) Mass resembling patella can be felt.

exercising articulation with the soft parts replaced, a condition met in the case of a knee joint where the patella is excised and the tendon of the quadriceps extensor femoris muscle sutured to the patellar ligament with quickly absorbable material.

"The patellar bone, therefore, is dependent in origin and structure. It is neither self made nor self supporting. Its genesis and continued existence in actuality are contingent upon the mobility of the knee joint and the pressure and tension, of remittent character,

produced by the activity of the quadriceps extensor muscle through its tendon that passes over the ventral aspect of the lower end of the femur."

FIG. 12. Case IV. Regeneration of the patella? (Thirty months.) A, preoperative x-ray of the left knee. B, same knee one month post-operatively. Note faint shadows representing early patellar regeneration. C, same knee thirty months postoperatively. Notice extensive patellar regeneration. One can feel what resembles a normal patella in this case.
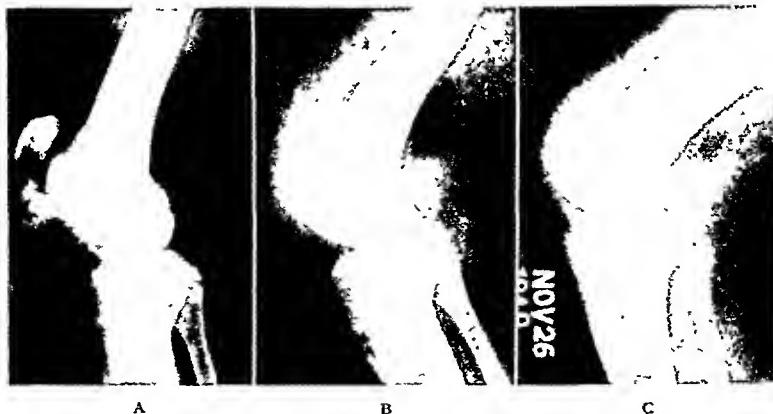
FIG. 13. Case V. Regeneration of the patella? (Eighteen months.) A, preoperative x-ray of right knee. B, same knee one month postoperatively. Note early evidence of patellar regeneration. C, same knee, eighteen months postoperatively. Note progressive regeneration. Patellar mass can be palpated.

In thirty dogs the process of regeneration was studied radiographically and microscopically after a segment of tendon including the entire patella had been removed and the remaining tendon ends reapproximated with chromic gut sutures. It was stated that ten to fourteen days after excision each dog recovered the use of the oper-

ated leg and the knee joint functioned as before the operation. Radiographic evidence of regeneration appeared early (seventeen to sixty days) and progressed rapidly in all dogs.

FIG. 14. Case VIII. Regeneration of the patella? (Nine months.) A, preoperative x-ray left knee. B, same knee one week postoperatively. Note the absence of any suggestion of regeneration this early. C, same knee nine months postoperatively showing patellar regeneration. Patellar mass can be palpated.
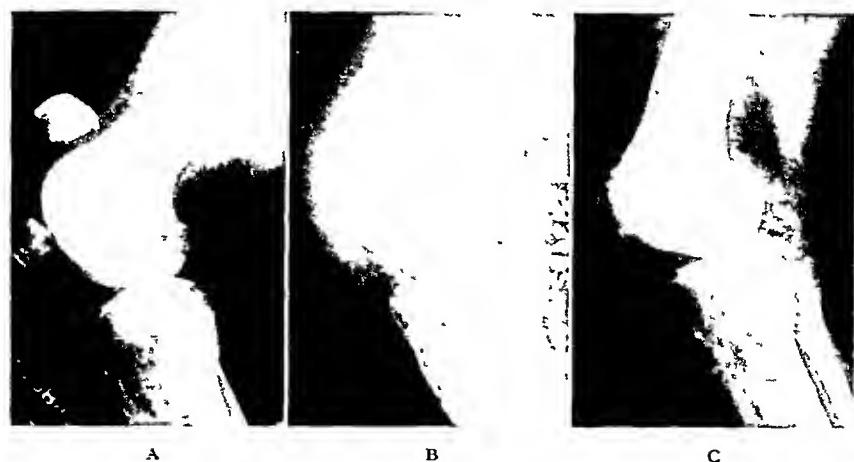
FIG. 15. Case IX. Regeneration of the patella. (Eight months.) A, preoperative x-ray left knee. B, same knee one month postoperatively. Note early patellar regeneration. C, same knee eight months postoperatively. Note extensive, progressive patellar regeneration in the relatively short time elapsed. Patellar mass can be palpated.

X-ray photographs were presented in the original article showing opacities in the repaired tendon at the original site of the patella, which were assumed to be evidence of regeneration. Though these areas, said to be bone, increased in size and density with time, x-ray evidence of complete regeneration of the patella was not demon-

strated. It was not stated whether any of the dogs subsequently developed a complete new patella, but it seems that sufficient evidence was presented to suggest an attempt at patella regeneration.
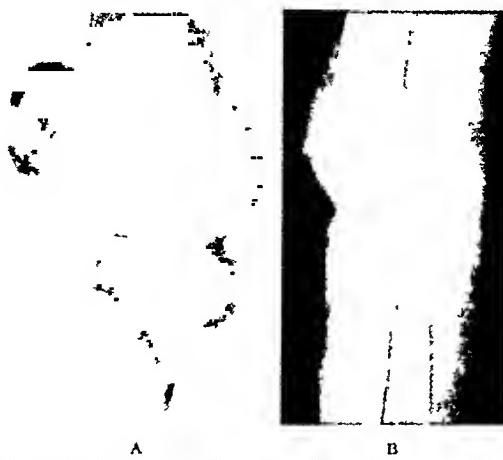
FIG. 16. Case XVIII. Regeneration of the patella?
(Three months.) Seventy-nine year old woman.
A, preoperative x-ray right knee. B, same knee
three months postoperatively. Note evidence
of early patellar regeneration in spite of
senility.

In our series of cases the same opacities, demonstrated as occurring in dogs, are shown by x-ray in the repaired human tendon at the original site of the patella. If these shadows are foci of regeneration, it has been constantly observed that radiographic evidence of same appears early and progresses with relative rapidity. In some of our earlier cases (1, 4, 8, 9) a cartilagenous mass conforming somewhat to the patella in shape, size and location, can be felt in the repaired quadriceps tendon. X-rays as early as one month postoperatively, show faint but definite irregular areas of density (proved to be bone) in the sutured tendon at the original site of the patella. These so-called areas of regeneration progressively increase in size, number and density with time but in no case (up to thirty-six months) have we been able to demonstrate by x-ray a complete new patella. Objective evidence of this suggested regeneration referred to, is furnished in Figures 11, 12, 13, 14, 15, 16, 17, 18 and 19.

Case 11, portrayed in Figures 17, 18 and 19 and referred to several times earlier in this paper, is of special interest. Strangely and sadly enough it was the only private case of the senior author. Because of unfortunate fatal pulmonary embolism it became possible to obtain for gross and microscopic study, the repaired and healed

FIG. 17. Case XI. Regeneration of the patella? (Seven weeks.) Fatal case autopsied. A, preoperative x-ray left knee. B, same knee one month postoperatively. Note marked early patellar regeneration. C, seven weeks postoperatively, x-ray anterioposterior through isolated quadriceps tendon. Specimen (fixed) obtained at autopsy. Vertical groove represents defect of section for photographic and microscopic study. Note irregular opacities representing patellar regeneration at this early date. (See Figs. 18 and 19.)

FIG. 18. Case XI. Quadriceps tendon removed at autopsy seven weeks postoperatively. Tendon repair grossly demonstrated. A, viewed from front. (Vertical defect extending through middle of specimen is the result of postmortem removal of sections for microscopic study.) Excellent repair is demonstrated. B, same as (A) showing repaired articular surface of tendon. The original site of the patella is seen as a relatively small oval depression. C, vertical section of the same tendon showing excellent restoration of continuity in the tendon. Observe bony deposits at original patellar site representing patellar regeneration well advanced as early as the seventh week. Arrows mark site from which microscopic sections were made. (See Fig. 19, A and B.)
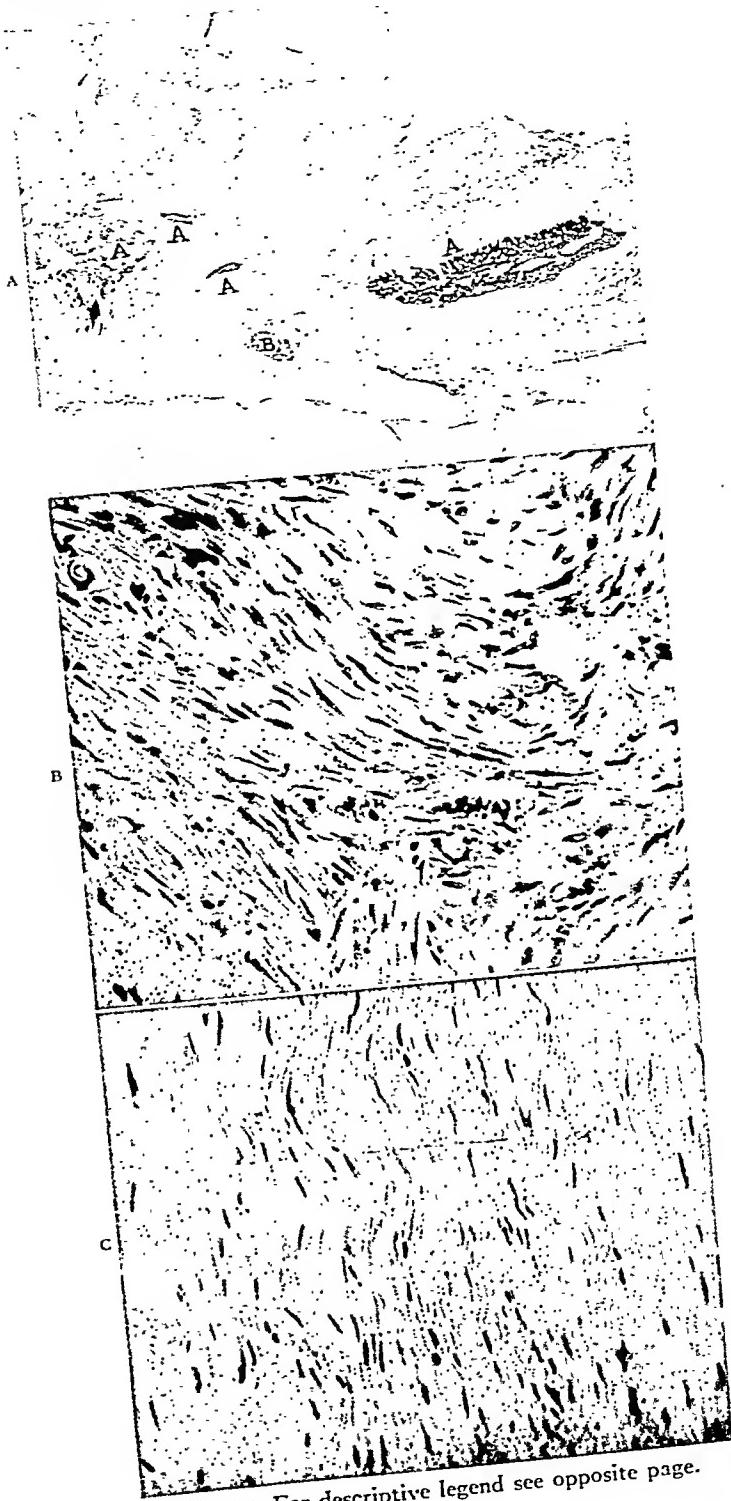
FIG. 19. For descriptive legend see opposite page.

quadriceps tendon from which the patella had been excised forty-seven days previously.

At autopsy the entire quadriceps tendon was widely removed and from studies of the specimen (gross, microscopic and radiographic) several interesting observations were made.

The site of repair of the tendon and expansions was excellently healed by primary intention. Scar tissue had completely and smoothly restored the continuity and there was surprisingly little chronic inflammatory reaction in or about the suture line. (Figs. 18 and 19.)

Upon examining the articular surface of the tendon (Fig. 18B) the original site of the patella could be identified as a smooth oval depression and in this patellar depression, could be seen and felt numerous, confluent, glistening, hard areas of bone suggesting evidence of patellar regeneration as demonstrated by x-ray so constantly in our cases.

Microscopic examination of the tendon through the suture line showed a pronounced degree of fibrous tissue proliferation with surprisingly little chronic inflammatory reaction and localized areas of young and growing bone were demonstrated throughout the sections examined. (Fig. 19A.)

SUMMARY

The authors believe they have demonstrated the superiority of the treatment of fractures of the patella by excision. As far as one can tell by careful examination of the cases, between three and forty-one months postoperatively, function is restored in all of the cases as completely as has been demonstrated in those several cases illustrated by photographs. It is possible to identify the affected knee only by the scar of the incision and the exaggerated prominence of the condyles of the femur. Flexion and extension, stability and power are unaffected by removal of the patella and the patients themselves frankly admit that their limb is as good as before injury.

It occurs to one that loss of the patella exposes the femoral condyles to trauma which may cause serious derangement of the knee joint. This criticism seems valid and though it has not yet occurred

Fig. 19. Microphotographs of repaired quadriceps tendon, Case xi. (See Fig. 18.) A, microscopic section through line of suture showing (A) bone, (B) site of silk suture. Fibrous tissue proliferation throughout. B, view of same area (higher power) showing pronounced fibrous tissue proliferation with practically no chronic inflammatory infiltration. c, for control purposes, same power as (B) section of normal quadriceps tendon from which the patella was excised postmortem. (See Fig. 1D.)

in any of our cases, would constitute a serious objection to the procedure were it not for the fact that regeneration of the patella probably takes place and when and if completed, should eliminate any unusual predisposition to injury.

CONCLUSIONS

1. The nonoperative treatment of fractured patella with separation of fragments is in general undesirable and unsatisfactory.

2. Arthrotomy with osseous suture as was suggested and advocated by Lord Lister in 1877, has been the treatment of choice for the past fifty years.

3. Though bony union, more rapid repair and better function resulted following arthrotomy and suture, much is left to be desired; and though a useful limb is as a rule obtained, in most instances considerable permanent functional loss persists.

4. Complete excision of the patellar fragments in those cases of fracture requiring operation is superior to any other treatment for the following reasons: (a) The operation is simpler and less time consuming; (b) convalescence is smoother and more rapid; (c) the period of hospitalization and disability is appreciably less; (d) earlier, more complete functional recovery is the rule; and (e) the late complications of osseous suture are eliminated.

5. In those cases from which the patella has been removed, the efficiency of the knee joint is in no way impaired. The range and rapidity of movement and the power is in no way inferior to that displayed in the opposite, intact limb.

6. There is evidence suggesting that following removal, regeneration of the patella occurs at its original site. If true, any attributed protective function would be eventually restored.

BIBLIOGRAPHY

1. Lister, Joseph. A new operation for fracture of the patella. *Brit. M. J.*, 2: 850, 1877.
2. Power, D'Arcy. Lister and wiring the patella. *Brit. J. Surg.*, 21: 558, 1933.
3. Dennis, Frederick S. Treatment of fractured patella by the metallic suture. *New York State J. Med.*, 43: 372, 1886.
4. Stimson, Lewis A. Treatment of fracture of the patella. *Ann. Surg.*, 28: 216, 1898.
5. Bull, W. T. The results of treatment of fracture of the patella without operation. *Med. Rec.*, 37: no. 12, March 22, 1890.
6. Powers, Charles A. The question of operative interference in recent simple fractures of the patella. *Ann. Surg.*, 28: 67, 1898.
7. Heineck, Aime Paul. The modern operative treatment of fractures of the patella. *Surg., Gynec. & Obst.*, 9: 8, 1909.
8. Corner, Eldred M. Figures about fractures and refractures of the patella. *Ann. Surg.*, 52: 707, 1910.

9. Chaput, Dr. Traitement des fractures de la rotule. *Semaine med.*, 11: 250, 1891.

10. Willis, W. Morey Nottingham-Chirurigical Society. *Lancet*, 11: 1689, 1907.

11. Scudder, Chas. L. *Illinois M. J.*, 13: 691, 1908.

12. Thomsen, J. E. M. Comminuted fractures of the patella. *J. Bone & Joint Surg.*, 17: 431, 1935.

13. Blodgett and Fairchild. Results of total and partial excision of the patella for acute fracture. *J. A. M. A.*, June 20, 1936.

14. Brooke, R. The treatment of fractured patella by excision. *Brit. J. Surg.*, 24: 733, 1937.

15. Groves, Ernest W. Hey. A note on the extension apparatus of the knee joint. *Brit. J. Surg.*, 24: 747, 1937.

16. Tippett, G. O. *Brit. M. J.*, page 383, Feb. 19, 1938.

17. Mehriz, M. M. *Lancet*, 1: 91, 1939.

18. Dodd, Harold. *Lancet*, page 130, July 15, 1939.

19. Carey, Eben J., Zeit, Walter and McGrath, Bernard F. Studies in the dynamics of histogenesis. The regeneration of the patellae of dogs. *Am. J. Anat.*, vol. 40, Sept. 15, 1927.

20. Lawrence, Howard Robert. Cases 6 and 20 private.

21. Burke, John. Cases 7 and 12 private.

22. Vogel, Henry Eugene. Case 10 private.

23. Fisher, Grant T. Cases 13 and 19 private.

24. Custer, Benjamin S. Case 14 private.

DISCUSSION

J. Huber Wagner (Pittsburgh, Pa.): Unfortunately, I got in a little late and so did not see more than the tail end of this beautiful movie. I have had the privilege of reading this manuscript of Dr. Dobbie's, however, and I do not know how much he was able to give of it, but I want to assure you that when it is published it will certainly be worth reading. It is one of the finest papers I have had the privilege of reading.

I am a little like the late and beloved Will Rogers, so far as this particular subject is concerned, for all I know about it is what I have read in the papers. I have not had any practical experience save, of necessity, on several occasions when I have had to take out some comminuted fragments of one of these cases of patella fractures.

Strange to say, at first, not knowing the work that had been done on this, I was very much worried concerning the end results, and was surprised to find that these patients do very well with a half and sometimes as little as a third of the normal patella.

Having read this paper, and seeing the end results as shown here, has certainly removed all the skepticism that I might have had concerning the wisdom of excising the patella. I do not know whether in the future, when I get a transverse fracture, I will be courageous enough to take it out—I am still a little slow on that—as we have had some very good results in our cases of fractured patella cases, believing that the essential thing after fixation was early function, i.e., both active and passive motion of the knee joint at an early date.

In Dr. Dobbie's cases, his average stay in the hospital in the twenty-one cases was about twenty-two days. I may be wrong about that figure. Our

average stay in the hospital is about the same. We get our patients up early and start them going.

This method, however, certainly shortens the convalescent period. As to the method or approach whether the transverse or the vertical incision is preferable, personally I believe that perhaps the vertical incision is the one of choice, as it does not interfere with the circulation, which is often a factor especially in elderly people.

As I said, I have no actual experience with this method, but it strikes me that probably the use of black silk is the suture material of preference. It has given us good results in many other joint operations and it certainly is well tolerated here.

Dr. Dobbie's paper shows a great deal of work and research from the historical point of view. This operation was used first of necessity and now as a matter of choice. Perhaps in the future we will lean a little more toward the employment of this particular method of excision of the patella at the time of fracture.

ROBERT I. HARRIS (Toronto, Ontario): It seems to me this is one of the most important contributions that has been made to our program, because it has demonstrated in a convincing manner that Brooks' claims and statements are true, claims which many of us had difficulty in believing, even though they were supported by the confirmation of Hey Groves.

We have had a brief experience with the method of treating fractures of the patella Immediately after Brooks published his paper, some of our fractures of the patella were treated by excision. Our results were unfortunate in that all ended with limitation of movement of the knee joint, some with gross limitation of the movement of the knee joint.

Why that was, I am unable to say, but Dr. Dobbie's presentation will lead us, I am sure, to return to the method with the hope and assurance that we can solve the problem of limitation of movement of the knee.

There can be no doubt that there are certain types of fracture of the patella which are difficult to treat by any method which attempts to repair the fracture, the badly comminuted case being the outstanding example. Moreover, I believe this presentation has demonstrated that it can be extended into another field, namely, the field in which osteoarthritis involves chiefly the patella, giving rise to a painful joint which is disabling out of all proportion to the osteo-arthritic lesion which is present.

I recently have had occasion to remove a patella for such a lesion, with the result which to date is extremely satisfying

THOMAS H. PETERSON (Boston, Mass.): I can add just a little in regard to the dislocation of patellas. I have had only one or two cases in which they have been removed, but the operation is far more satisfactory than any of the transplants which we might have used, and even in the transplantation of the patella tendon. I think we are going to find that this

procedure is going to be a great help along with our other procedures in treating the dislocating patella.

PHILIP D. WILSON (New York City): I can echo what has been said already, and particularly because I have seen localized osteo-arthritis in several old cases which previously had had fractured patellas, had been sutured with excellent results which persisted over a period of years, and then eventually developed this localized type of osteo-arthritis between the femur and the patella. The relief of this symptom is by excision of that patella.

There is one thing that is important to point out, that is, that the patella will regenerate again in a good many of these cases. You will not get the same sized patella as originally, but you will get ossification developing which will make a considerable show.

I do not believe that is a harmful thing; I am sure Dr. Dobbie has seen this. I do not think it is at all harmful, nevertheless you should not be surprised if a year or two later you find you have a new patella.

ROBERT P. DOBBIE (closing): Briefly, I do not know why Dr. Harris did not get good results equal to ours. I am sure we cannot excise patellas any better than he and his group can. Our results have all been very excellent; so excellent that it is hard to believe.

In reply to Dr. Peterson's remarks, a British surgeon, I think it is Tippet, advises very strongly against operating on a recurrent or dislocating patella by excision. It makes them worse, he says, not better. He tried it in two cases, and gives that as one definite contraindication.

In commenting on Dr. Wilson's remarks on regeneration, I dare not say much about regeneration. I thought I knew something about it, but the more I think about it the less I know about it. In seven of our cases they began to show at the end of the month, new bone in the quadriceps tendon at the site of the patella. In four of the cases they have what feels like a patella, a cartilaginous mass. There are a lot of things I do not know about this, and whether it is a regeneration or an effort at regeneration, I cannot say.

THE LOCAL THERAPEUTIC EFFECT OF SULFATHIAZOLE

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THE surgical management of open wounds and surgical infections by chemotherapy is by no means a new procedure.

The advent of the sulfonamide group of chemicals has recreated a widespread interest in one of man's first surgical problems. Today medical science is fulfilling Ehrlich's early prediction of the discovery of chemicals having bactericidal and bacteriostatic properties without deleterious effect upon human tissues.

Our early work with the sulfonamide drugs involved the treatment of general and local wound infections by direct application of the crystalline chemical at the site of the infection. We became impressed by the apparent absence of any gross destructive or irritative effect upon human tissues and the rapid disappearance of the infection. In view of the abundance of heavily contaminated traumatic wounds and compound fractures, which come to our service, we conceived the idea of preventing the development of infection in these cases by the local administration of the drug during the time period of contamination.

We were further impressed by the excellent work of Jensen following the local application of sulfanilamide crystals in the treatment of compound fractures.

Our work in this field constituted a study of the clinical behavior of sulfathiazole* in the treatment of compound wounds, compound

* The supply of sulfathiazole was made available by a grant from the Winthrop Chemical Company.

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fractures (recent and old), various types of surgical wounds and infections and use of the drug intraperitoneally in abdominal surgery.

In our present paper we are presenting the results of the local application of sulfathiazole in fresh compound wounds, compound fractures and simple fractures requiring operation.

Having little available information as to the behavior of the drug, when applied locally into wounds, our procedure and technic were carried on with considerable caution in order to evaluate the drug's real worth.

In all cases cultures of the wounds were taken immediately following inspection. Positive cultures representing a wide range of pathogenic organisms, including the various types of gas bacillus, were reported from the cases of contaminated and potentially infected wounds.

However, it was found that during the period of contamination (four to six hours after injury) the number of organisms recovered by routine bacteriological studies were few. Cultures taken from the compound fractures were positive in 50 per cent of the cases and in soft tissue wounds 32 per cent were positive.

It is quite apparent that the pathogenic contaminators during the above period had not as yet reached a reproductive stage in which they were sufficiently numerous and virulent to present evidence of invasion or active infection.

The above findings coincide with the already existing opinions regarding the value of débridement during this period when the organisms are few in number and low in invasive properties. Débridement of contaminated wounds, as practiced in recent years, has contributed much toward the prevention of wound infection. Its practice as a preliminary phase of surgical management of wounds should continue as a standard principle in treatment.

During our present study, we have changed our usual technic of handling wounds and compound fractures in only two respects: (1) application of sulfathiazole crystals directly into the wounds, and (2) complete closure of all wounds without drainage.

In all cases, the drug was applied locally and distributed throughout the cavity by means of a sterile cotton applicator or sterile gloved finger. It is important that the powder reach all tiny recesses, fissures and corners. The extent of the wound and the type and condition of the tissues involved determined the quantity of drug to be implanted.

The crystals were implanted as dispensed from the original container prepared in 5 and 10 gr. powder papers. No attempt was made to sterilize the crystals prior to their use, even though this can be effected without chemical change to the drug.

In a number of cases, surgical repair of the damaged parts was delayed by shock, hemorrhage, heart, lung and other complications. Sulfathiazole was applied locally as a prophylactic agent in these cases with operation at a later date.

Whether complete repair and reduction were performed immediately, or delayed, all wounds were closed completely without drainage and immobilized by splints when indicated. Our results have been most gratifying as shown by the following tables. (Table I.)

The first series consisted of fifty-eight compound fractures, as listed in Table I. All wounds were of major proportions concerning their locations, with considerable muscle as well as other soft tissue damage. Open reduction, when indicated with internal fixation, was performed immediately if the patient's general condition was satisfactory, or delayed if necessary by shock, hemorrhage or other complicating factors. In all cases, however, a large quantity of sulfathiazole was diffused thoroughly throughout the wound and about the fracture site. This was followed by immobilization of the injured parts using plaster splints whenever needed. An operative procedure was found necessary in 89.6 per cent of these compound fractures.

It will be noted that only 50 per cent of this series showed cultures positive for pathogenic organisms. This observation is not unexpected in view of the fact that almost all of these cultures were taken within six hours of the time of injury. At this period the infective bacteria had not yet begun to multiply nor had they become invasive to any great degree. It is during this latent period that the local application of sulfathiazole has the greatest prophylactic value.

Analysis of the percentage figures of infection (10.3 per cent) developing in compound fractures after using sulfathiazole, at first glance does not appear impressive. Of the six patients developing infection, two occurred in severe leg injuries in which the circulation of the distal portion of the limb was entirely destroyed. Gangrene resulted necessitating amputation at the fracture site. Pathogenic organisms were cultured from the wound sites and there was a liquefaction necrosis of the gangrenous tissues; for this reason, we classified these two cases as infected. It seems unfair to expect the drug to prevent the development of bacteria in completely necrotic

tissue which has absolutely no normal defensive mechanisms. In both cases, the viable tissues proximal to the site of injury, were healthy and showed no clinical evidence of infection. Following amputation, the stumps healed with remarkable rapidity. We

TABLE 1

CONTAMINATED COMPOUND FRACTURES—PROPHYLACTIC LOCAL USE OF SULFATHIAZOLE

Compound Fracture of	No. of Cases	Positive Culture on Admission	Deaths	Operations	Infections	Toxic Reactions	Results
Femur. ...	2	1	0	2	1	0	Infected case had loss of circulation of lower leg with gangrene necessitating amputation. Infection minimized.
Tibia and fibula	14	—	0	14	1	1 microscopic hematuria 1 drug fever and rash 2 delayed union	Infected case had loss of circulation below fracture site with gangrene necessitating amputation Infection minimized.
Humerus. . ..	2	2	1	1	1	0	Infected case developed gas gangrene after drug was discontinued, and died.
Radius and ulna	2	1	0	1	n	0	
Tarsal	1	1	0	1	0	1 delayed healing	Marked destruction soft tissues foot.
Metatarsal	1	0	0	1	0	0	
Metacarpal	1	0	0		0	0	
Phalanges..	27	11	0	23	2	2 delayed healing 1 headache, vomiting and microscopic hematuria	One infected case developed infection only after oral drug was stopped—no local drug. Second infection apparently failure of drug to prevent infection
Skull	3	2	3	3	1?	1 hematuria, hepatitis, renal failure?	All 3 cases had severe brain damage and died within several days. Infected case developed mastoiditis.
Face bones ...	5	3	0	5	0	0	
Total	58	20	4	52	6	0	
Per cent		50	6.9	89.6	10.3	15.5	

propose, therefore, to eliminate these two cases as being failure of sulfathiazole to prevent infection in compound fractures. A third patient sustained a fractured skull compounded through the mastoid and middle ear. Local application was impossible in this instance and we feared to give extremely large doses orally or intravenously

due to already impaired vital signs. We believe that the development of mastoiditis was not due to a failure of the drug *per se*. An impossible situation existed in this case with severe shock, severe brain trauma and renal failure.

By removing these three cases from our figures, the corrected incidence of infection drops from 10.3 per cent to 5.4 per cent. This value is extremely low for a series of compound fractures and it becomes particularly significant in view of the fact that the entire group was composed of consecutive cases as they were admitted to our service and not a selected series of patients. The majority of these fractures were produced by crushing injuries in mining accidents with considerable comminution of the fractures and severe trauma of the soft tissues.

The remaining three cases of infection require some comment. One compound fracture of a finger developed a mild infection after the oral use of the drug was discontinued; sulfathiazole was not applied locally at the time of injury, but local applications following the development of the infection controlled it rapidly. The second case was one of a compound fracture of thumb. This wound continued to drain a purulent exudate for several weeks in spite of repeated local applications of the drug. We are unable to explain the failure of prophylaxis here. The third patient sustained a compound fracture of the humerus in the proximal third with complete traumatic amputation. The muscles of upper arm and shoulder were badly mutilated and Clostridium welchii was reported from cultures. The patient received large doses of sulfathiazole locally and by mouth. His condition improved materially during the first four hospital days. At that time, the drug was discontinued orally and within twelve hours a virulent gas gangrene of shoulder and chest developed which was fatal within another twelve hours in spite of all treatment. Although cultures from five other cases showed Clostridium welchii this is the only one which developed gas gangrene following prophylactic use of the drug. It is our belief that large doses of sulfathiazole given both locally and orally within three or four hours of injury and continued for nine to fourteen days will prevent many cases of gas gangrene. Sulfathiazole has not been so effective in the treatment of active gas gangrene in our experience.

The wounds of the other fifty-two cases in this series healed without infection, in a manner approaching primary union, save for an occasional discharge of a clear, nonpurulent, serosanguineous exudate.

The constitutional and local reactions from the drug were closely observed in all the cases presented in this series. Wound inspections were made to observe any reaction, discharge, progress of healing, lymphangitis, adenitis and swelling; also frequent urine analyses, nonprotein nitrogen observations, and frequent blood level estimations were obtained. Careful observations were made for any local or general toxic manifestations, which, if they occurred, were given

TABLE II

CONTAMINATED TRAUMATIC WOUNDS—PROPHYLACTIC LOCAL USE OF SULFATHIAZOLE

Traumatic Wound of	No. of Cases	Positive Cultures on Admission	Deaths	Opera-tions	Infec-tions	Toxic Reactions	Results
Scalp..	4	0	1	0	0	0	Death occurred from other injuries and complications
Face	4	2	0	3	0	1 delayed healing	Delay due to persistent serum collection
Neck	2	2	0	1	0	0	
Shoulder	1	0	1	0	0	0	Death occurred from complicating injuries and cerebral embolus
Arm..........	2	1	0	2	0	0	
Forearm	1	0	0	0	0	0	
Hand	4	1	0	3	0	1 delayed healing	
Fingers	5	0	0	4	1	1 delayed healing	Infected case of anaerobic streptococcus resistant to drug
Rupture urethra	1	0	0	1	0	0	
Penis and scrotum	1	1	0	1	0	0	
Anal sphincter	1	1	0	1	0	0	
Thigh..	2	2	0	2	0	2 delayed healing	
Lower leg	1	0	0	1	0	0	
Foot . . .	2	0	0	2	0	1 delayed healing	
Total	31	10	2	21	1	6	
Per cent. ..		32.2	6.5	6-.8	3.2	19.3	

immediate consideration and treatment. As noted in Table 1, 15.5 per cent of cases showed one or more toxic reactions. Except in one instance, these reactions were of a mild character and continued administration of the drug was possible. The exception was the case of the patient with a compound fracture of skull with meningitis who developed a toxic hepatitis with jaundice and died. It is highly questionable whether death was due to toxic reaction from sulfathiazole, however, as the severe brain injury plus meningitis and mastoiditis were sufficient cause for death. The other three deaths in this

series were due to severe brain damage following compound fracture of skull (two cases) and gas gangrene of shoulder (referred to previously). (Table II.)

The second group consisted of thirty-one soft tissue wounds, similar in all respects to those listed in Table I, except for the presence of a complicating fracture. Treatment and observations were instituted in a similar manner. As was found in the previous group the number of positive cultures upon admission during the period of contamination was again found to be low—32.2 per cent. In 67.8 per cent of cases the wounds were of sufficient magnitude and gravity as to require an operation for repair of the parts. Healing comparable to primary union occurred in twenty-five cases of this series of thirty-one. Five of the cases of this group showed a moderate delay of healing due to a collection of serum within the wounds or to a loss of soft tissues to such an extent as to make complete repair of the wound impossible. Only one case of this series showed infection. This wound involved a finger. Despite the continued local application of sulfathiazole following the usual technic of repair, a superficial and persistent infection developed. The exudate was purulent and foul-smelling and repeated cultures showed an anaerobic streptococcus. Response was finally obtained after six weeks' application. It is our feeling that this organism is highly resistant to the drug. The two deaths which occurred in this series were caused by complicating injuries, not associated with the soft tissue wounds, which were treated with local applications of sulfathiazole.

There were no general or systemic toxic reactions in this group, due, primarily to the fact that only a few cases received the drug orally (in addition to local application) and in small doses.

In Groups I and II we have noted twelve cases of delayed healing of the wounds and two cases of delayed union of the fractures. We cannot definitely ascribe the delay of healing and union to a toxic reaction of the drug; however, we feel these findings should be mentioned and offer a field for further investigation. (Table III.)

Group III constituted a series of simple fractures which were operated upon because of gross displacement of the fragments. These cases represented clean, noncontaminated areas. The implantation of the chemical served as a prophylactic agent in maintaining surgical asepsis of the wound as well as a means of investigating wound changes. The amount of the drug implanted depended upon the size and character of the incision. The incisions were closed completely and healed by primary union. There were no infections

in this series. There were three cases of delayed formation of callus; this cannot be definitely ascribed to the drug but should be kept in mind as a possibility. There were no deaths in this series and no general systemic reactions to the drug.

TABLE III

SIMPLE FRACTURES REQUIRING OPERATION—PROPHYLACTIC LOCAL USE
OF SULFATHIAZOLE

Simple Fracture of	No. of Cases	Positive Cultures on Admission	Deaths	Opera-tions	Infec-tions	Toxic Reactions	Results
Femur..	8	..	0	8	0	2 delayed union	
Tibia.. .	5	..	0	5	0	1 delayed union	
Patella.. . .	3	..	0	3	0	0	
Malleolus.	2	..	0	2	0	0	
Metatarsal.	1	..	0	1	0	0	
Humerus. .	2	..	0	2	0	0	
Clavicle. .	1	..	0	1	0	0	
Total .. .	22	..	0	22	0	3	
Per cent.. ..	..	..	0	100	0	13.7	

In our discussion of these preceding series of cases, we shall confine our remarks to the local and general reactions following the application of sulfathiazole locally. The toxic reactions of the drug following oral administration have been reviewed by numerous writers. We shall not discuss this phase of the problem in this paper except to state that in the series of cases presented, the only serious toxic reaction which occurred was the development of a toxic hepatitis in a case of compound skull fracture referred to previously.

We attribute the infrequency of serious reactions (following oral administration) in our cases to the policy of insisting that all patients receive an abundance of fluid by mouth and, when indicated, saline and glucose intravenously. By this means the drug is eliminated rapidly and at the same time the urinary concentration of the drug is kept at a low level decreasing the possibility of forming renal calculi and tubular concretions. All patients also received, unless contraindicated, high protein and high vitamin diets with supplementary administration of vitamin c.

Recent experimental work by Martin, Fisher and Thompson have indicated that several of the intermediary products of protein metabolism and vitamin c besides being natural detoxifiers of body poisons, also act to reduce the toxicity of the sulfonamide drugs and

at the same time enhance their therapeutic effectiveness. The rôle of proteins and vitamin c in promoting the natural processes of wound repair is well known.

There has been considerable discussion regarding the exact mode of action of the sulfonamides. For the present, they can best be described as having a bacteriostatic effect.

Lockwood, in a recent article, stated that "the therapeutic result in a given case of established or threatened infection will depend upon the adjustment of three principal variables; namely, the concentration of sulfonamide maintained in the immediate environment of the bacteria, the mobilization of the cellular defense (which of course varies in different tissues), and the concentration of sulfonamide inhibitor substances."

The principles of treatment, which we have used in this series of cases, utilize each of these factors as favorably as possible. By applying the drug locally and closing the wound without drainage, a high local concentration of sulfathiazole is maintained in the immediate region of the contaminating bacteria. This concentration is much higher than can be secured by oral administration and as the drug is absorbed rather slowly over a period of four to six days a constantly high local concentration is obtained.

It has been shown experimentally that peptone, p-aminobenzoic acid and other protein degradation products act as inhibitor substances to the action of the sulfonamides, restricting the chemotherapeutic effectiveness of the drug to a marked degree. It has also been shown that these inhibitor substances are derived from the decomposition of injured, nonviable tissues, such as are always present in traumatic wounds, and from the degenerating cell bodies of the bacteria themselves. A thorough débridement of all wounds is, therefore, important to remove the source of these inhibitor substances. It is also important that the sulfathiazole be applied during the time period of contamination before the bacteria have an opportunity to multiply to a state in which they may of themselves become an inhibitor substance.

We have found novocaine to be an inhibitor substance; hence the use of local anesthesia is advised against in all cases in which sulfathiazole is to be used as prophylaxis against infection.

If nonviable tissues are removed from the wound and the proliferation of bacteria is prevented, it is obvious that the natural defense mechanism of the host will be able to function to the best advantage.

At the outset of our studies we were particularly concerned regarding the effect of sulfathiazole on the soft tissues themselves to which the drug was applied. The absence of local irritation to the
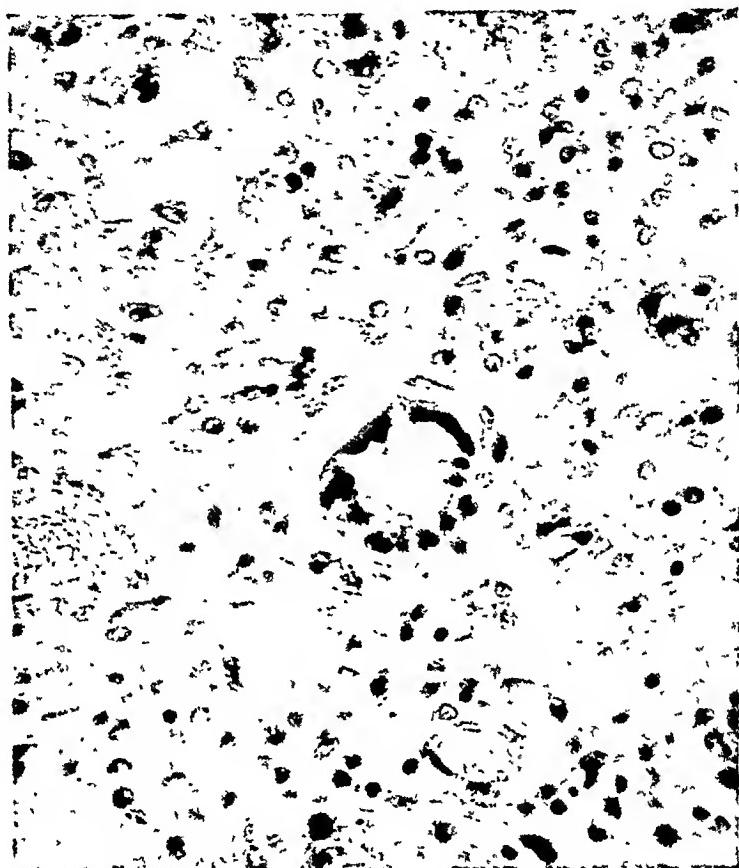
FIG. 1. Foreign body giant cell reaction around sulfathiazole crystal in granulation tissue. (High power.)

wound has been very striking. For the most part the wounds have healed completely in a normal period of time without undue accumulations of serum and without any unusual production of scar tissue. We have had occasion to examine microscopically sections of tissue to which sulfathiazole had been applied (taken from cases of delayed wound healing, removal of bone plates, etc.). In no instance was there any microscopic evidence of any interference with the normal processes of healing. The granulation tissues had a normal appearance; there was adequate production of collagen, and the capillaries and fibroblasts were proliferating normally. We are thus unable to account for the occasional case of delay in healing.

One of the sections studied showed a peculiar phenomenon. The tissue was a biopsy of granulation tissue taken from a case of healing

osteomyelitis. The microscopic picture resembled ordinary granulation tissue except for the presence of occasional scattered foreign body giant cells, each of which surrounded what was presumably one or more crystals of sulfathiazole. There was no other cellular or histologic change to differentiate this section from any of the others studied. In none of the specimens was there any unusual cellular reaction to indicate irritation aside from the giant cells as mentioned. (Fig. 1.)

Further evidence of the absence of local irritation from direct application of the drug crystals has been obtained from our abdominal and joint surgery. In several cases of two-stage intestinal resections and in several autopsies, we have observed the absence of any unusual intraperitoneal adhesions. Traumatic lacerations in a number of cases involved joint capsules. Following healing of the wounds, the joint motions were found to be restored to normal.

No subject of the type presented in this paper would be complete without comprehensive bacteriological studies. The problems which are presented by these studies are numerous and will require further experimental investigation. A thorough bacteriological study of these wounds, many of which show mixed infections, may help to standardize the selection for treatment of one or more of the various sulfonamide drugs as the bacteriological study may indicate.

Experience with a great number and variety of cases enables one to recognize early toxic manifestations of the drug and to differentiate the toxic lesions from other allergic reactions and acute skin dermatoses. Certain of our cases (in other fields of surgery to be reported in a later paper) have proved very susceptible to local and oral administration of sulfathiazole regardless of the quantitive factor or time period of administration. If a patient is sensitive to the drug, he will obtain just as severe a reaction from a small dose as from a large one. This observation has been made independently by several of the clinicians outside of our own group. We believe, therefore that if sulfathiazole is to be used at all, it should be used in adequate dosage so as to secure the full chemotherapeutic effect. Only two patients of our total of some 500 receiving the drug developed toxicity to such a degree that we were forced to discontinue the use of the chemical.

In view of the encouraging results which we have obtained to date following the local use of sulfathiazole to wounds during their period of contamination, we believe that these studies should continue. It is suggested that this method of treatment of wounds may

serve as a most valuable factor in the prevention of infection and the saving of human life in military and war injuries.

CONCLUSIONS

1. The results of the local use of sulfathiazole· in compound wounds, compound fractures and simple fractures requiring operation have been presented.

2. Reduction in the incidence and severity of infection in these wounds was demonstrated.

3. Toxic manifestations following the local use of sulfathiazole was discussed.

4. The supposed mode of action and recommendations regarding treatment have been made.

REFERENCES

THOMPSON, W. D., RAVDIN, I. S. and FRANK, IRVING I. Effect of hypoproteinemia on wound disruption. *Arch. Surg.*, 36: 500, 1938.

JENSEN, N. K. et al. The local implantation of sulfanilamide in compound fractures. *Surgery*, 1: 6, 1939.

CAMPBELL, W. D. and SMITH, HUGH: Sulfanilamide and internal fixation in the treatment of compound fractures. *J. Bone & Joint Surg.*, 22: 959, 1940.

HAVILAND, JAMES W. and LONG, PERRIN H. Skin, conjunctival and scleral reactions in the course of therapy with sulfathiazole. *Bull. Johns Hopkins Hosp.*, 66: 313, 1940.

LONG, PERRIN H. Thiazole derivatives of sulfanilamide, sulfathiazole and sulfamethylthiazole. *J. A. M. A.*, 114: 870, 1940.

RAKE, GEOFFREY and MCKEE, C. M. Action of sulfathiazole and sulfamethylthiazole on staphylococcus aureus. *Proct. Soc. Exper. Biol. Med.*, 43: 561, 1940.

REINHOLD, JOHN G., FLIPPIN, HARRISON F. and SCHWARTZ, LEON. Observation on the pharmacology and toxicology of sulfathiazole in man. *Am. J. Med. Sc.*, 199: 393 1940.

LONG, PERRIN H., HAVILAND, JAMES W. and EDWARDS, LYDIA B. Acute toxicity, absorption and excretion of sulfathiazole and certain of its derivatives. *Proct. Soc. Exper. Biol. & Med.*, 43: 328, 1940.

GROSS, PAUL, COOPER, FRANK B. and SCOTT, RUTH E. Urolithiasis medicamentosa. *Urol. & Cutan. Rev.*, 44: 4, 1940.

MARTIN, G. J. et al. Therapeutic and prophylactic detoxication. New York, 1940. In press.

FLEMING, A. Antiseptics and chemotherapy. *Proct. Roy. Soc. Med.*, 33: 127, 1940.

WOODS, D. D. The relation of p-aminobenzoic acid to the mechanism of the action of sulfanilamide. *Brit. J. Exper. Path.*, 21: 74, 1940.

REED, G. B. and ORR, J. H. Chemotherapy in experimental gas gangrene. *Lancet*, p. 376, March 22, 1941.

KEY, J. ALBERT and FRANKEL, CHAS. J. The local use of sulfanilamide. *Ann. Surg.*, 113: 284, 1941.

LOCKWOOD, JOHN S. The mode of chemotherapeutic action of the sulfonamides. *Surgery*, vol. x, No. 3, 1941.

TREATMENT OF FRESH TRAUMATIC WOUNDS

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IN a previous publication[1] the results of an experimental evaluation of methods of initial treatment of fresh contaminated wounds was reported. This report was based upon two groups of experiments carried out in rabbits. In one group, a representative series of bacteriocidal agents "antiseptic solutions" were placed in incisions and injected into the subcutaneous tissues. These solutions consisted of 70 per cent alcohol, tincture of iodine, tincture of green soap, ether and three of the commercial preparations most commonly employed in the United States. The tissues of areas of incision and sites of injection were examined microscopically. In each instance there were demonstrable degrees of tissue injury varying from edema and cells with pale staining nuclei to gross necrosis with abscess formation. Ether caused the least and the tincture of green soap the most severe tissue injury. In the same way the effect of isotonic salt solution and of sulfanilamide upon tissues was determined. Neither agent caused demonstrable injury to tissues.

If the bacteriocidal agents always rendered wounds free of bacteria, the injury to the tissues caused by them would be a relatively unimportant consideration. The failure of these antiseptic solutions to prevent infection of contaminated wounds was demonstrated by the second group of experiments. Compounded wounds with fractures of the radius were inoculated with mixed cultures of hemolytic colon bacillus, Staphylococcus aureus and hemolytic streptococcus. These wounds then received a thorough application of one of the antiseptic solutions enumerated above and were closed without drainage. Suppuration occurred in the majority of wounds and in many instances the fractures failed to unite.

In another series in which identically compounded and inoculated wounds were irrigated copiously with isotonic salt solution and the tissues covered with sulfanilamide powder there was no suppuration. All wounds healed *per primam* and all fractures united normally.

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From these experiments it may be concluded that (1) chemical agents capable of destroying bacteria also devitalize or destroy tissue cells; (2) antiseptics do not render all contaminated wounds free of bacteria; (3) sulfanilamide implanted directly into wounds does not injure tissue cells significantly; (4) isotonic salt solution does not injure tissues; and (5) copious mechanical washing of contaminated wounds with isotonic salt solution followed by the topical application of sulfanilamide powder was much more effective in preventing infections than the application of antiseptic solution and did not alter the normal reparative processes.

These experimental observations merely confirm *clinical impressions* held by many surgeons.

Also reported in a previous publication were the results obtained in twenty-five consecutive cases with major fresh wounds treated by (1) thorough débridement, (2) copious washing with salt solution, (3) implantation of sulfanilamide powder, and (4) primary closure in all but two cases. All cases received this treatment within eight hours of the time of injury and in twenty of the twenty-five cases there was good evidence from history or by fact that soiling of the wounds had occurred either by penetration of a foreign body or by exteriorization of bone. In eighteen cases excised tissue was cultured and from fourteen positive cultures were obtained.

TABLE 1

Type	No.	Result		
		Primary Infection	Healing per Primam	Healing Delayed*
1. Compound fractures..................	14	0	6	8
2. Major lacerations..................	9			
4 severed tendons				
1 traumatic amputation of arm.......	..	0	7	2
3. Extensive shot gun wounds...........	2	0	0	2
	25	0	13	12

* Devitalized skin edges separated and healed by granulation.

The series consisted of fourteen compounded fractures of major long bones, nine major lacerations and two shotgun wounds received at close range. The results are briefly summarized in Table 1. Not one patient in the entire series developed a primary infection or a subcutaneous suppurative process and in thirteen or slightly more

than 50 per cent of cases the wounds healed *per primam*. Both shotgun wounds, one of the thigh and one of the flank, were left open because it was impossible to close them after the torn wound margin had been excised. In eight of the fourteen cases with compound fractures and in two of the nine with major lacerations there was failure of primary healing and separation of portions of the approximated skin edges. This we attributed to devitalization and disturbed circulation of the edges of the flaps as a result of the original trauma and to tension. In all but one of these cases retraction of the flaps left only small superficial surfaces which healed by granulations. All fractures in this series united and in no case did osteomyelitis develop. One compound fracture of the tibia recompounded when the skin flaps retracted. As soon as this occurred the portion of the crest of the tibia which was exposed was excised and the flaps re-approximated. Healing with no appreciable retraction followed. When a skin flap evulsed from the crest of the tibia is sutured, it is stretched over dense bone from which there is no angioplasia and healing is dependent entirely upon the small surface of skin-edge contact with the other flap. To provide a wide contacting surface capable of immediate angioplasia and incidentally to lessen tension on the flaps much of the underlying crest of the tibia was cut away with a chisel in a recent case and primary healing resulted.

PLAN OF TREATMENT

The general plan followed in the treatment of these patients consisted first of all in the immediate control of hemorrhage and the rapid alleviation of shock when these conditions were present. Examination and other forms of therapy were deferred until there had been a satisfactory recovery from shock. There followed then a complete evaluation of the injuries. This included roentgenograms as indicated and detailed examinations for evidences of loss of function of individual tendons and nerves. Inquiry into the possibility of and special examination for evidence of injuries of the urinary bladder and other hollow and solid viscera were made when indicated. Some form of anesthesia, local, spinal or general, was then administered and the wounds cleaned and débrided.

In the compound fractures in which one of the fragments protruded through a laceration of the skin no attempt was made to replace this fragment until it had been thoroughly cleansed. We believe that this principle should be followed whenever facilities for

thorough cleansing are immediately available. A fragment which has been exteriorized is always soiled and the soft tissue bed from whence it emerged is often either totally or relatively sterile. Therefore, cleansing the fragment before replacing it accomplishes the major act in preventing infection and also avoids contamination of the soft tissues. Before the exteriorized fragment was cleansed the skin for a wide area about the wound was rendered surgically clean by scrubbing it with a sterile hand brush for three or four minutes with a stream of sterile water and green soap constantly flowing over the area. The bone was then washed by gentle brushing of all surfaces with a new sterile brush, while normal salt solution (and only salt solution) was constantly poured over it. Solutions other than saline such as soap and antiseptics were used only in preparing the skin and were never permitted to come in contact with the tissues.

In those cases in which the soiled fragment had been replaced before the patient came into our hands we exteriorized this fragment after the skin had been cleansed and washed it as described above.

Before replacing the fragment in either case all parts of the wound were irrigated with large quantities of normal salt solution. It must be emphasized at this time, as it will be repeatedly, that these irrigations must be copious, using many liters of saline. To be successful the principle of mechanically washing contaminants from the tissues necessitates the use of large quantities of saline, washing in and out of every recess of the wound. The wound should be retracted as necessary to expose its entire extent and all surfaces should be gently agitated with gauze while the solution is flowing over them.

The fragment was then replaced and all torn and devitalized bits of fat, muscle and fascia excised. Because crushed skin does not heal readily and often separates, the crushed and devitalized margins of the skin flaps were excised whenever feasible. The wound was again copiously irrigated with normal salt solution, its surfaces covered with a thin layer of sulfanilamide powder and the skin closed, usually without drainage.

The fractures were reduced through the open wound in most instances and after skin closure in others. It is our opinion that if these fractures have been thoroughly cleansed and prepared, as outlined above, they may be handled essentially as clean simple fractures. This applies to the use of metallic and other foreign material for internal fixation. Whenever indicated we have made use of internal fixation and have had no occasion to regret it.

The technic of cleansing compound fracture wounds in which there was no protruding fragment, and of all other types of wounds, differed only in respect to one important detail. This, the initial step, consisted of closing the wound temporarily with Michel clips to prevent soiling it while the skin was being prepared. This not only prevented the dirty wash water from running into the wound but also permitted scrubbing across the approximated skin edges. After the skin had been rendered surgically clean the clips were removed and the wound opened widely, irrigated and débrided. If the laceration of the skin was too small to permit adequate exposure for purposes of inspection, débridement and irrigation, it was enlarged. Regardless of the degree of soiling, severed tendons and nerves in wounds treated within eight hours after the time of injury were sutured immediately. This can be done with little risk of infection if the wound has been properly prepared by copious irrigations and thorough débridement and by the topical application of sulfanilamide.

Tetanus antitoxin was administered routinely. Clostridium welchii perfringens antitoxin was not used. Routinely, we gave all wounds immediately a course of x-ray therapy upon the assumption that these rays are as effective in preventing infection from Clostridium welchii and other gas forming anaerobes as they are in the treatment of established infections.

All wounds of the extremities were immobilized either in traction or by splinting or casting. If a cast had been applied, a small window was immediately made to expose the wound for purposes of frequent direct inspection and palpation. The plaster casts in most instances were nonpadded.

All patients with major wounds were hospitalized for at least forty-eight hours. During this period they were kept at complete bed rest with the injured part, if an extremity, elevated above heart level. This period of hospitalization was insisted upon to assure constant observation by trained observers. During this period a minimal fluid intake of 2,500 cc. was maintained by mouth or parenterally when the oral route was not available or adequate. Blood was given until relatively normal levels of hemoglobin and red cells had been attained. Vitamin B-complex and C were given in therapeutic doses routinely.

REFERENCE

1. BISGARD, J. DEWEY and BAKER, CHAS. P., M.D. Treatment of fresh traumatic and contaminated surgical wounds. *Surg., Gynec. & Obst.*, in press.

DISCUSSIONS OF PAPERS OF DR. WEIL AND DR. BISGARD

PHILIP D. WILSON (New York City): I want to say that I think both of these presentations of Dr. Weil and Dr. Bisgard are very thorough presentations of quite profound studies, and I am sure that they must be convincing to all of us that chemotherapy, both locally and generally, represents a real advance in the treatment of contaminated and infected wounds.

We are all thinking today in terms of military surgery and what can be done to prevent serious infections in the military cases that are being produced abroad and may soon be produced in our own forces.

There are certain points that I think ought to be made in relation to the treatment of air raid casualties. In the first place, they tend to have multiple wounds. These multiple wounds involve perhaps as many as a hundred or more small penetrations of the skin.

Most of these are minor, but no one can tell where one of these things may strike a vulnerable structure like an artery or a nerve and cause serious damage, so that every one of them has got to be inspected very carefully in order to be sure not to overlook some serious injury.

In the second place, most of these patients show shock. We know that the blast of high explosives can produce death even without visible wounds. Many corpses are found after air raid attacks on which there have been no marks at all of external wounds, and all of these people who have sustained wounds have been exposed to the effect of the blast. If blast can kill, it can also produce shock, and all of these patients are shocked. It tends to make the surgeon very wary in his approach as to what he is going to do, and so the surgical approach to the treatment of these patients is definitely conditioned by these two factors.

There is also a third factor, and one which is not given enough attention, namely, the condition under which the operative treatment is carried out. During an air raid attack, you may be without light, water, electricity or heat, and consequently the treatment of many of these patients has to be postponed until better conditions can be obtained.

Again, there is the factor of oppressive work. A great many cases accumulate in one hospital, and the surgeon is laboring under great pressure. In addition, is the fact that the operating rooms in many of the hospitals have been improvised in the subterranean vaults of the hospital for greater safety. Their trained crews have been taken away, and they have a team that is not as thoroughly trained as it might otherwise be.

Now, we all know that even under civil conditions there are operating rooms which for one reason or another are not such that they present ideal conditions for an aseptic operation, and this is certainly true under war conditions, and this definitely influences what you can attempt to do in the early treatment of these patients.

One must arrange one's operation, carry out one's treatment with a view to dealing with later infection, and this is particularly true because there is such variation in the types of the wound. You may have a small wound produced by a small missile, causing the butterfly type of fracture and not making an exit. On the other hand, you may have a fragment of shell casing entering through a small wound, producing comminuted fracture of the bone, and then imparting motion to those fragments so that they are thrown out; then you have a huge wound of exit and a very badly shattered comminuted fracture.

Another thing, we believe in the operation of surgical cleansing carried out, I think, in Dr. Bisgard's technic. As he describes it, it would be ideal if it could be carried out and one had the time to do it. One ought to aim at least to do it.

Following that, we should use chemotherapy in the wound, and while sulfanilamide is probably the least irritating of the drugs, I personally prefer sulfanthiazol, because of its greater activity against various strains of organisms, and particularly against the gas-producing organism.

There has been a good deal of work done showing that sulfanilamide has practically no effect against Bacillus welchii while sulfathiazol does have a very definite effect.

The splinting of these fractures represents a problem, and we believe in the closed treatment of these wounds and in dressing them and not disturbing them for as long a period as possible. If a thorough surgical cleansing operation can be performed in the first instance, and if then this wound can be shut up, even if it is allowed to granulate, it seems to me that we can expect the best type of healing.

I said that the closed plaster treatment was being carried out in England extensively. I mean by that, the Orr-Trueta method of treatment; and if the wound is properly treated in the first place, infection can be largely prevented. The wound is packed with gauze and then sealed over and treated in plaster, and is not disturbed again until there is some definite indication for doing so, either in the way of toxic reaction, fever or complaint of local pain.

Local pain is one of the greatest guides, I think, in controlling the progress of the case. These patients should be comfortable, and if they complain of pain it always means that there is something going wrong locally and demands investigation. I think the Orr-Trueta method of treatment is being used universally.

ROBERT I. HARRIS (Toronto, Ontario): We might with profit ask Dr. Bisgard and Dr. Wilson to comment on what seems to me to be a most important and critical aspect of the treatment of compound fractures, as demonstrated by the presentations before us today.

Dr. Bisgard has shown us excellent results and beautiful technic in the treatment of compound fractures in civil life, in which he has treated

the wound by primary closure, a method which I think has a great deal to recommend it in civil life.

Dr. Wilson, dealing with war wounds, is going to show us a film dealing with the treatment by the Orr-Trueta method in which the wound is packed open and heals.

I think this presentation would be incomplete unless we discuss the merits of the treatment, aiming at primary closure and primary wound healing as against a method in which healing by granulation is striven for. In what cases may we hope for primary union? In what cases shall we close the wound? In what cases must we use vaseline pack?

PHILIP D. WILSON (New York City): This first case being shown is a compound fracture of the femur that had been treated by surgical cleansing. B.I.P. had been put in the wound and primary closure had been done. This patient reached us some four days after injury with his fracture in a very bad alignment, and we treated this patient by insertion of the Anderson apparatus to get and maintain alignment.

The incision is closed and covered with a dressing. This case went on apparently quite well in plaster. At the end of four weeks, the plaster was changed, and at this time it was found that the wound had broken open, was suppurating and discharging very foul material. After that it had to be treated, of course, with the wound packed open.

We finally got union, but he still has a sinus some six months after operation. I think the result in this case would have been distinctly better if he had been left open in the first place and the wound allowed to heal by first intention.

The Anderson apparatus gave us an ideal method, particularly in the case of a femur, of attaining reduction and maintaining alignment, together with complete fixation. In these badly comminuted fractures, it is quite impossible to use internal fixation. You would have to use or depend upon distraction, assuming there are so many fragments that it would be impossible really to put them all in alignment. Certainly in the treatment of the wound I believe that complete immobilization is of tremendous importance in promoting the local, definite reaction and preventing infection.

Therefore, we put in pins and then incorporated the whole thing in plaster. In other cases in which we could do so, we put on a side bar locking these pins in place, and then applied our plaster over the whole apparatus. That had the advantage that when we went back to do a second dressing, our alignment was maintained when the plaster was removed, and we did not have to line the fracture up all over again

In this case I had a pin through the tibia. When he came to us we left it in place but put a Kirschner wire through the lower end of the femur and a double Anderson pin in the upper fragment. This case did not require immobilization of the hip, as the other fragment was adequately controlled by the upper pin.

These patients can frequently be allowed to get up at the end of three or four weeks. We do not allow weight bearing, but it is a great help to morale if they can be ambulatory. We do not insist upon it, but it is purely a question of whether the patient feels well enough to do so.

Another of our patients was a bombardment casualty who suffered a compound fracture. He came to us four days after injury. This man's wound was tremendous. There was extensive comminution of his femur. When he first arrived he was already infected. His wound was full of Bacillus welchii and mixed flora. We washed out the wound, made sure of a thorough drainage, packed the wound with sulfathiazol, reduced it by the Anderson apparatus which maintained complete fixation even though the plaster had been removed. The wound was packed with gauze and wrapped in plaster. He has made very considerable progress.

I think that the best method of applying sulfathiozol is with an insufflator, but we had difficulty in getting them and we had to use the best method we could. We used our sulfathiazol. It was prepared in sterile powder, and we had it in doses varying from 2 to 7 Gm.

At the next dressing four weeks later, our pin units still held and the patient had very good alignment of his fracture. He will have full length. As a matter of fact, I have just had a follow-up on this case from Dr. Cole, saying that they have taken out the pins at the end of five months, that there is local infection about the pins but nothing at all serious. The patient will probably discharge a small ring sequestrum. His wound is now represented by a small draining sinus, and he now has union.

You see there has been very considerable progress in the healing of this wound. We were afraid to use these pins in such close approximation to an infected wound, and particularly closing it up with plaster, where inevitably these pins are going to be bathed in pus.

We gave the patient sulfathiazol orally as well as locally, and I think this tided him through the period in which the invasive type of infection might take place.

In twenty-eight cases that I now have notes on of compound fractures in which pins were used, we had no serious infection and no case in which the pin had to be removed.

The fixation in this case is so complete that we can apply a short plaster now and permit knee flexion, but the plaster is a means of sealing off the wound, preventing any gross contamination.

G. Gavin Miller (Montreal, Quebec): There is little to add in discussion of these excellent papers and Dr. Wilson's exhaustive discussion.

In handling recent sounds one factor needs emphasis: This is the necessity of thorough cleansing and débridement of wounds in order to get healing by first intention. All wounds treated in this way within six hours of onset should heal without infection. I find it difficult to persuade the house staff to do this with sufficient thoroughness so that freedom from infection is assured.

With dependence on sulfathiazol to prevent infection, even greater laxity may be expected in wound cleansing which is to be deprecated. In my opinion, the most important procedure in early wound handling is thorough cleansing.

I do not think it necessary to leave a wound open if inflicted less than six to eight hours before treatment is instituted, as a very large percentage of these will heal by first intention if cleansing is adequate.

If a wound has been inflicted eight or nine hours, or more, before being seen by the surgeon, the wound should be left open and packed. There is no time to say more but I would like again to express my appreciation of these excellent papers.

Henry C. Marble (Boston, Mass.): I am very much interested in these papers. They present two sides. I am very much interested in chemotherapy. We saw the word "contaminated"; we saw the word "infected." In all infection, I want to know how they knew they were contaminated. With all respect, I want to know how they knew they were infected. We have no control.

I have made it a rule that any wound which is cleaned up and in which one of the sulfa derivatives is put in, first that the material removed shall be put in an aerobic and an anaerobic culture. Then, when we are talking about wounds sterilized by these chemicals, we shall know whether or not they ever were infected.

I would like to ask Dr. Bisgard in all sincerity if he will put in his moving picture a couple of broth cultures, putting that contaminated material as it is removed into a broth culture. Then show us the Bacillus aerogenes capsulatus growing. In that way we will know with what we are dealing.

I think we shall make it an absolute rule in all these cases that before we report the results, we know whether or not the wound was primarily infected with organisms that were going to cause trouble.

Grover C. Weil (closing): In reference to Dr. Marble's questions relative to the period of contamination and preliminary wound cultures, we believe they are essential factors in the consideration of prophylaxis, infection and wound healing. Preliminary cultures have been taken of all wounds at the time of inspection. The quantitative recovery of the primary contaminators as a rule were low, the variety many and undoubtedly at this point low in virulence and invasive properties. If the environmental state of the wound is favorable for certain of the contaminating organisms, the period of contamination becomes shortened and infection develops. We have arbitrarily set the period of contamination at four to six hours.

Our results to date in the prophylactic and local use of sulfathiazol have been most impressive and encouraging. The use of the drug in the prophylaxis and treatment of surgical infections should, by no means, interfere with the modern principles of standard surgical technic in the care of injured tissue such as débridement, etc.

J. Dewey Bisgard (closing): Dr. Harris brought out the difficulties of using this type of technic for the type of wound occurring in military practice during war. I agree that there would be some difficulty in providing the very large quantities of sterile salt solution but I think it is not unsurmountable. It could be transported and supplied in tanker trucks or nonbreakable containers. However, the time element is a real obstacle and would probably prohibit the very wide use of copious irrigations at the front. It requires usually a couple of hours to clean a large wound and handle it in the way demonstrated.

More recently I have used a combination of both sulfathiazol and sulfanilamide; I mean, using both drugs in the wounds. However, Keyes, of St. Louis, has shown that sulfanilamide is more effective than the other sulfonamides in preventing infection in contaminated wounds in animals.

In reply to Dr. Marble's remark, I restate that in twenty of the twenty-five cases there was evidence that foreign bodies had entered the wounds, or that the bone fragments had been exteriorized. It is inconceivable to me that a fragment could protrude through the flesh and clothing, with dirt all about, without being contaminated.

In eighteen out of the twenty-five cases cultures were taken from the wound at the time of débridement and positive cultures were obtained in fourteen.

TRAUMATIC ABDOMINAL SURGICAL EMERGENCIES

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TRAUMA of the abdomen constitutes an important group of injuries not only producing disability but also ending far too often in sudden death. Much of this is due either to entire lack or to slow application of proper emergency treatment. Far too often a patient arrives at the hospital with an abdominal trauma, having received no emergency care at the site of the accident. Irreparable damage is likewise done through improper handling by well meaning but inexperienced persons. Many times the injured person is placed in the first available automobile; he is rushed over roads and streets at a high rate of speed, thereby damaging the traumatized abdomen still more and increasing the shock with every jolt and turn.

The medical profession must realize the importance of prompt and proper first aid treatment for patients with abdominal trauma. Naturally physicians must be thoroughly trained in the fundamentals of first aid and in appreciating the importance of first aid for this class of patients. Every member of this organization needs to go forth and preach the gospel of first aid to physicians so they can direct the laity and can actively promote better emergency care to cases of abdominal traumas. Such first-aid service is possible through the training of those who are brought in contact with accident cases. This is especially important in modern warfare as abdominal trauma is exceedingly common in military activity.

It is also necessary for interns to know the principle of first aid for abdominal trauma while serving on the ambulance or in the emergency room at the hospital. The general practitioner likewise renders emergency treatment to cases of abdominal trauma. He should be prepared to handle those he is capable of treating, but he should not fail to recognize early those he is not equipped to treat. The physician who accepts a case of abdominal trauma for treatment beyond the emergency is responsible for the end results, not the surgeon who sees the case when failure is imminent. Likewise a surgeon who assumes the responsibility of treating these patients must be willing to accept

many patients for exploration. He must be willing to give them much of his time, making painstaking examinations, performing extensive technical operations, giving that close postoperative attention which in itself will do much in reducing the mortality rate.

"Treat them where they lie" is truly the first principle in the emergency treatment of abdominal traumas as well as of fractures. This treatment should begin immediately at the scene of the injury and should first combat shock, then check hemorrhage and relieve pain. If shock is profound, no movement whatsoever should be allowed until improvement has occurred. Many lives have been sacrificed through subjecting patients in shock from abdominal traumas to the added traumas of transportation.

Abdominal trauma may be parietal, visceral or parietovisceral; it may be closed or open. Any abdominal trauma calls for immediate close attention; therefore, the patient should be carefully examined to determine the diagnosis. In many cases a history, carefully taken and recorded, and a physical examination are sufficient for a correct diagnosis. Others require laboratory examinations before a diagnosis can be determined.

The trauma may be limited to the abdominal wall, but one must be certain of this fact. With a closed trauma of the parietes the pain and tenderness are usually localized to the site of the trauma. Among the closed traumas are ruptures of the rectus muscle and deep epigastric vessels. The commonest site is below the umbilicus. Profuse hemorrhage follows rupture of the deep epigastric vessels; it is frequently difficult to differentiate between hematoma of the abdominal wall, intraperitoneal, and retroperitoneal hematoma. However, with the first the swelling in the abdominal wall protrudes prominently if the patient blows with the nose held tightly, while an intraperitoneal or retroperitoneal mass will disappear. If the intraparietal hematoma is large and increasing in size, it must be evacuated; bleeding vessels must be clamped and ligated; any rupture of the muscle should be carefully sutured. There may be a great deal of damage to the parietes with the loss of much tissue. One should consider every incised, lacerated, or puncture abdominal wound as potentially penetrating, until it is proved otherwise.

Most open wounds of the abdominal parietes, regardless of how dirty they are, if seen early, i.e., within four to six hours, can be cleansed and prepared so that primary union occurs. Nevertheless, despite meticulous cleansing there are some wounds so heavily contaminated that infection occurs. Furthermore, there are some

virulent types of contamination which the body defenses seem
impotent to combat. The abdominal wall should be shaved, then
scrubbed with green soap and warm water until it is quite clean. The

FIG. 1.   FIG. 2.

FIG. 1. Anteroposterior view of abdomen showing bullet entering abdominal
    wall through left side, perforating the left lobe of of the liver, diaphragm,
    pleura, lung, again the pleura, and a compressed fracture of the body of the
    vertebra with compression of the cord.

FIG. 2. Lateral view of location of bullet in relation to the spine.

skin surface thereafter should be rinsed thoroughly with sterile water,
dried, and washed with ether. All foreign material visible in the
wound must be removed; tissues which are obviously devitalized
must be excised. Irrigate the wound thoroughly with normal saline
solution, forcing this into all crevices of the wound. A chemical
bacteriocide can be applied to the normal skin of the abdominal wall.
One should cautiously explore the depth of the wound to make
certain that it is limited to the parietes or that it enters the abdomi-
nal cavity. There must, of course, be complete control of hemorrhage.
This should be followed by the placing of from 5 to 10 Gm. of sterile
crystalline sulfanilamide in the depth of the wound. Wound closure
with the least number of annealed steel wire, cotton, or silk sutures,
without tension, will usually result in primary wound healing.
Wounds too extensive for satisfactory approximation of the edges,
can have a plastic repair if the patient's condition permits; otherwise,
pack with vaseline gauze and protect with dressings or pack open and
irrigate with Dakin's solution every two hours. Plastic repair can be
done when the patient's condition warrants it. Naturally, one would

give antitetanic serum after testing for sensitivity. The patient should be closely observed and given such treatment as indicated.

Notwithstanding the improved preoperative preparation and the

Fig. 3. Ruptured viscus (stomach) in supine posture, showing only elevated diaphragm on right.

postoperative treatment of today, perforating abdominal wounds have approximately the same mortality as twenty-five years ago. The mortality rate increases in proportion to the age of the patient and the size of the missile. Incised, stab, or gunshot wounds may enter the peritoneal cavity, yet cause no damage to the viscera; however, they may, and probably will, introduce contamination resulting in a fatal peritonitis. The majority of persons with penetrating abdominal wounds die within twenty-four hours from hemorrhage and shock. Those dying after this time succumb to peritonitis. Many incised and stab wounds appear to be limited to the parietes; yet as has been suggested, these must be considered potentially penetrating until proved otherwise.

There are no reliable symptoms sufficiently constant to indicate the absence or presence of visceral traumas. With the presence of general muscle rigidity and tenderness, pain and pallor, one can be fairly certain of an intra-abdominal trauma. Even in the absence of clinical symptoms of an intra-abdominal trauma, indication for surgical intervention is always present. Patients arriving at the hospital in a serious state of shock should be treated for this condi-

tion before an examination is made. If after three or four hours the pulse rate continues rapid with a falling blood pressure and a reduction in the hemoglobin and red cells, or if air hunger develops, one

Fig. 4. Same as Figure 1, in upright posture showing free air or gas under diaphragm.

can be certain that hemorrhage exists. Therefore, an early operation is imperative, provided there is any reasonable prospect of the patient surviving the operation. Patients apparently in suitable condition should be sent to the operating room for examination. As you know, many patients require very close study to determine the advisability of operation. The surgeon naturally will use every means at his command to aid him in reaching a conclusion. The best surgical authority available should be called into consultation. Roentgenograms should show the presence of free air or fluid in the abdominal cavity. The peritoneoscope will also be a valuable aid in determining if there has been a penetration with blood or intestinal contents extravasated into the peritoneal cavity. With every facility available to meet emergencies, enlarge and explore the wound to its depths. If the incised or puncture wound has entered the abdominal cavity, an exploratory laparotomy must be performed as every perforating

wound of the abdomen means a probable perforating wound of the gastrointestinal tract or some other viscus. Eviscerated omentum should be resected before the abdomen is opened or explored.

FIG. 5. Intra-abdominal trauma with pelvic fracture and rupture of bladder shown by extravasation of fluid in cystogram.

FIG. 6. Same as Figure 5, after healing of bladder defect following open surgical repair.

Eviscerated intestines should be cleansed by irrigating with warm normal saline solution and flushed with ether. Perforations should be closed before the intestines are returned to the abdomen.

Gunshot wounds of the abdomen frequently produce profuse hemorrhage and profound shock. Most of the fatal cases succumb within a few hours. They are so quickly fatal that no type of treatment offers hopes of benefit. Even apparently hopeless cases, however, should be given every chance for recovery. The immediate intravenous administration of acacia, plasma or serum and normal saline solution may prove a lifesaver. Patients in shock must be treated for this condition and observed frequently. When the patient fails to recover from shock in three or four hours, it is reasonable to suspect that the condition is due to actual blood loss; therefore, prepare the patient for exploration as soon as the blood pressure has been raised to a level at which a laparotomy can be fairly safely performed. Patients arriving at the hospital without much evidence of shock should be taken to the operating room immediately for examination and preoperative preparation. A careful history should be taken and recorded. The physical examination must be thorough and the findings recorded. The bullet's wound of entrance and exit is particularly important; an imaginary line connecting these two

wounds will indicate the course of the bullet through the body and the probable resulting trauma. If the bullet is still in the body, a flat x-ray film should be made and quickly developed to provide informa-

FIG. 7. Extracapsular rupture of left kidney; pyelogram showing diffused material in kidney area and loss of kidney outline.

FIG. 8. Rupture of the right kidney; pyelogram showing intracapsular extravasation of diotrast about kidney pelvis.

tion regarding the location and size of the missile. It is often difficult to determine the optomal time for operation; yet the most important element aiding the recovery of patients with bullet wounds of the abdomen is a short interval between the injury and the operation. The decision whether to operate immediately or not is usually based on the rate and character of the pulse and the blood pressure reading. Patients showing a reduction in the pulse rate with an increase in its volume and a satisfactory blood pressure rise are probably good risks for operation. One with a feeble pulse of 120 or over and a blood pressure of 90 mm. or under is in a grave condition and could hardly be expected to survive an operation; therefore, every effort should be made to improve the patient's condition before an exploration is undertaken.

Regardless of the location of an incised or punctured wound through the abdominal wall, intra-abdominal exploration requires a long midline or a paramedian incision. As soon as the abdomen is

opened, blood clots and semisolid fecal material should be removed with the hands; then the cleansing process may be continued with suction until finally a complete toilet of the abdomen and its contents may be made with sponges wrung out of warm normal saline solution. Next check all hemorrhage by seeking out the bleeding vessels and ligating individually, avoiding mass ligation and devitalization of tissue. Thereafter systematically examine for trauma to the viscus. This may reveal many injuries.

Percutaneous abdominal traumas usually result from direct force applied to the abdominal wall; they rarely occur from indirect force due to muscle effort. Trauma caused by blunt violence are of two types; the widespread traumas caused by a severe crush, and the limited lesion following a sudden local trauma. Crushing injuries are usually multiple, often producing death within a short time. The limited trauma is the most dangerous. Frequently there are no external signs of trauma and symptoms of visceral trauma may be absent soon after the accident. Circumscribed blows more commonly injure the stomach and intestine when distended, also the bladder; on the other hand, diffuse force is apt to result in trauma to the more fixed and solid organs, such as the retroperitoneal colon and duodenum and the liver and spleen. Percutaneous injuries produce many types of traumas. Among these are, contusion and rupture of the free large and small intestine, retroperitoneal rupture of the colon and duodenum, tearing of the mesentery from the intestine, tearing of the mesenteric vessels, tearing of the omentum, trauma of the mesenteric, omental, and splenic vessels with resulting infarcts, rupture of the liver and spleen, together with an associated rupture of the bladder, kidney, and diaphragm, postperitoneal hemorrhage or a combination of any of these. These injuries are frequently fatal because their seriousness is not recognized early; accordingly, emergency treatment is neglected, hospitalization is late and since diagnosis is frequently difficult, appropriate treatment is delayed. Patients arriving at the hospital after an accident, apparently in good condition, should be carefully examined for trauma. Even with lack of symptoms and no evidence of a trauma, they should be put to bed and observed frequently. Blood pressure readings and pulse rate should be taken every half hour. Often in the presence of a ruptured viscus, definite symptoms may develop slowly. The presence of an acute abdominal pain, of muscle rigidity, and tenderness with an anxious expression, of pallor, of an increasing pulse rate and a falling blood pressure should make one suspicious of a serious abdominal

trauma. Therefore, a careful examination should be made to determine the cause of the patient's condition. In many cases a carefully taken and recorded history and a painstaking physical examination are sufficient for the diagnosis. Though under some conditions a definite diagnosis can not be made, time spent in attempting such a diagnosis, and in preparing the patient for an operative procedure, will still reward one for the effort, for this time will give a decreased morbidity and a lower mortality.

Associated traumas to the bladder, kidney and diaphragm are common in both penetrating and percutaneous intra-abdominal traumas, therefore, they should be looked for in all such cases.

Recent advances in surgery have taught us to be more careful in evaluating the patient's fitness for surgery. Preoperative preparation of the patient, pre-anesthetic sedation, and the postoperative care are frequently of more importance than the operation.

Contamination of the peritoneal cavity by penetrating wounds or percutaneous rupture of hollow viscus does not invariably require drainage; many cases do well without drainage. One should, however, make an effort to remove contaminating foreign material from the peritoneal cavity at the time of the operation. Patients frequently die of spreading peritonitis because absorbed toxins have not been adequately neutralized. The local and general immunity are the processes which actually protect. We have used Coli-Bactragen in a considerable number of perforated and ruptured wounds of the intestine, and we believe that the results obtained justify continuing the procedures. Also, the prophylactic use of sulfanilamide in these cases has apparently resulted in a marked reduction in the morbidity and mortality. Though it is true that peritonitis of traumatic origin is a polymicrobic infection and that sulfanilamide is not fully effective against all the bacteria present, still other conditions appear to be favorable for the therapeutic action of the drug.

A large number of patients surviving an operation performed within the first six hours after such traumas will recover if given close attention and proper postoperative treatment. Complete rest and good nursing are essential.

CONCLUSIONS

The reduction of the high mortality due to traumas of the abdomen lies first and foremost in the dissemination of much of the information embodied in this paper. There is little here that has not previously been said. Many are as familiar with this subject as the

author; and yet at the same time there are many physicians engaged in general practice who have not had the opportunity to inform themselves on much herein outlined.

But equally, and perhaps of greater importance, is the need for instructing the laity in proper procedure when an accident occurs. It is indeed rare for a physician to be first at the scene of an accident; and in those first precious moments there are a few simple procedures the layman could do—or abstain from doing—that would expedite the surgeon's task enormously and would save many lives that are now needlessly being sacrificed.

DISCUSSION

HENRY C. MARBLE (Boston, Mass.): I think at the moment there is little to add. Perforating wounds of the abdomen, as Dr. Palmer has pointed out, are important and require organization once they are in the hospital.

There is across the river from Boston a little hospital in an underprivileged community, in which we occasionally have cases of perforating wounds of the abdomen, often with stilettoes, sometimes with bullets. The rules for the junior staff in that hospital are that all perforated wounds of the abdomen shall be explored with no delay.

The advent of blood banks has made it possible to proceed boldly to the operation, and to rescue the patient from the shock or from the increasing shock with blood or blood plasma or saline.

Recently at a staff meeting, a young surgeon presented his case. He told about the patient having been impaled upon a stiletto, and as he presented his case he stated that the white count was 10,000. The only criticism of the presentation (he had a nice operation and repair to the wound) was that one gentleman inquired why they bothered with the white count.

Now, the other group of cases are, as we see them, mostly children. In Chelsea, apparently, it is the favorite diversion of the child in the street to throw himself under the passing automobile, and the history as they arrive in the hospital definitely states that the wheel of the automobile went right across the child's abdomen. That presents all of the picture.

Here, again, the only thing I can say is that the blood bank is of value. But as far as I am concerned, the junior surgeon or the resident in charge can cancel all appointments for the next twenty-four hours, and if he cancels all appointments and sets himself down beside the patient and does nothing else, I think mortality will be on the decrease. He, and he alone, is the only person equipped to evaluate the changing conditions, and the more closely he sticks to that patient the better able he is to evaluate the necessity for exploration or for operation.

D. C. PATTERSON (Bridgeport, Conn.): The subject assigned to Dr. Palmer is so big, that it is very difficult to cover it in a short time. I want to

compliment him on the field he has taken in. The treatment of these injuries, as he says, requires the best surgical skill, with all that implies, namely, preoperative study and preparation, meticulous and competent operative care and very conscientious after-treatment.

There is not a great deal that can be done at the scene of the accident. These patients, you might say, have automatically splinted the abdomen. They can be kept warm, shock can be reduced and morphine administered, but they should be gotten to the hospital as soon as possible.

The most important thing in the early stages is the careful observation and study of the patient himself, and it is well to bear in mind the truism of Gorrel, that "where one mistake is made by not knowing, ten mistakes are made by not looking."

The external wound on the patient may give little indication of the seriousness of the internal injury. We had one patient come in—a street sweeper—and the only accident that he could report was that in pulling his brush toward him he struck the handle of his brush against the lower left flank. He later complained of pain and was sent to the hospital. We found that he had a rupture of the sigmoid. Fortunately, he made a good recovery.

We had, two winters ago, as the result of coasting accidents, three cases on the service at one time; a ruptured kidney, a ruptured spleen and a ruptured liver. To put it briefly, we left the kidney alone, removed the spleen, and packed the liver, this was in a girl of nineteen, with a huge crack across the dome. They all made very good recoveries.

In the matter of kidney injuries, before one should ever think of removing the damaged kidney, he should be sure that the other kidney is properly functioning. I know of a case in which a damaged kidney was removed three or four days after an accident, so it hardly seems as if it were necessary, without the other kidney having been investigated. Unfortunately, the only kidney that he had was the one that was removed.

In injuries of the spleen, the matter of delayed hemorrhage has been brought to our attention. We had a patient that developed hemorrhage seven days after a baseball blow in the region of the spleen. Fortunately, he had remained in the hospital all the time. I think if we had been real smart, we would have known the state of the spleen and removed it before it ruptured.

There is one thing the doctor spoke of that I cannot quite agree with, that is, the drawing of the straight line between the wound of entrance and the wound of exit of the bullet. It has been our experience that the course of a bullet in the human body is about as erratic as a downhill putt; you never know what is going to happen after a bullet enters the body.

Just one thing further which I should like to mention. They have strange ways, probably, in Bridgeport, but we have had several cases of compressed air rupture of the intestine. Three of these I have had personal experience with, only one of which came to the hospital in time for operation. The

others were admitted in a moribund state. One of them was malicious, one was a joke and the other was purely accidental.

In regard to the way these things can happen, the men in the foundries had a habit, at the end of the day's work, of dusting each other off with a compressed air hose. It is not necessary for the nozzle to be inserted in the anal opening, or even in the buttocks; if it comes within six inches, the conformation of the buttocks produces a funnel through which air can enter the intestinal canal.

It is well to warn all safety men in factories against this very pernicious practice of dusting off the clothing with compressed air.

CHARLES JOHNSTON (Detroit, Mich.): Dr. Palmer has painted a rather bright and pretty picture of how to handle these surgical emergencies. In the case of a stab wound or gunshot wound, I think I can agree with him that we can outline fairly well what to do. The problem is not one, as Dr. Marble suggests, for a resident to watch; it is one for the entire staff. The more experienced person must be perfectly willing to get up in the middle of the night and wrestle with this problem. Too frequently, these patients are brought into the emergency room, a diagnosis is hoped to be obtained there, and a decision made on whether or not to operate. Usually these patients are much better off if taken to their beds and allowed to get some rest and then studied. During this interim, of course, blood transfusions should be given to combat hemorrhage or shock and any other problem which they present should be met.

The difficulty in diagnosis is extreme. Many of these patients may show very little in the beginning after very severe intraperitoneal trauma; others may show signs of tremendous shock and have nothing wrong with their viscera at all.

Two complicating features have caused us difficulty in diagnosis in the cases which have not had real trauma to the intra-abdominal structures but which simulated it. These are acute dilatation of the stomach, and rigidity of the abdomen associated with fractured ribs. Frequently, patients with minor trauma will have an acute dilatation of the stomach and will appear practically moribund when brought into the hospital. These will respond quite rapidly to relief of the distention. Chest injuries, especially fractured ribs, may cause enough rigidity to suspect that the patient has a fullblown peritonitis.

Dr. Charles Henry, of our staff, has carried out studies on perforations, especially ruptured ulcers in which the acid is allegedly high, and his data indicate little harm from chemical effects. The same things hold for the ileum also, i.e., that the chemical aspects of the peritonitis are of very minor importance. It is the bacteria that are present, and the fact that many individuals have not found bacteria means that the organisms have been so diffused by the inflow of fluid that a decent culture is not obtained.

Dr. Henry found that if he takes a large enough quantity of material, the bacteria will usually be found. Furthermore, he has found that the chemical composition of the intraperitoneal fluid after ruptured ulcers is practically that of blood serum. In other words, the ill effects of the chemical (the acid or the alkali) are pretty well neutralized. We have not studied enzymes, however, and it is possible that the enzyme may be a dangerous factor.

The greatest complications that we have seen are, of course, bleeding and peritonitis. Frequently we have seen, without other injury, mesenteric injury, i.e., bruise to the mesentery and subsequent thrombosis of the mesenteric vessels. It is practically impossible to diagnose the situation before death. The patient gets a marked ileus which is assumed to be the ileus based on trauma, which we of course see quite commonly in these cases and which, if intubated and allowed to right themselves, will recover. If marked vascular occlusion is present, death ensues.

I think this has been a very interesting subject. I want to point out that you cannot differentiate trauma to the abdomen from trauma generally, and attempts to farm out the care of these patients on an anatomical basis are absurd. Segregation of head injuries on the neurosurgical service, or chest cases on the chest service is not so good for the patient as it might seem. The patient must be looked at as a sick individual who has been traumatized, and must be cared for as a whole; he cannot be divided among various services. Someone has to take the responsibility for the patient.

CORTICAL EXTRACT IN THE TREATMENT OF SHOCK*

PRELIMINARY REPORT

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SINCE the work of Swingle and associates,[1] and others, on the possible rôle of cortical extract of the adrenal gland in the prevention and treatment of shock, much interest has naturally been developed in the problem. In general, there has not been any consistency in the opinions and results of experiments. A part of this inconsistency may, no doubt, be due to variations in dosage of the extract, and potency of the various agents used. Recently, synthetic products (corticostesterone and desoxycorticosterone) with cortin activity have been made available for use. Selye and associates[2] found that cortical extract was very effective in the prevention of shock in rats, but that desoxycorticosterone was not effective. These results have been confirmed by Weil and associates[3] who noted that when cortical extract and desoxycorticosterone acetate were given together, the mortality rate was reduced in rabbits subjected to manipulation of the intestine, but was not reduced following administration of the latter drug alone. Our experience is confined to the treatment of dogs subjected to shock producing factors such as hemorrhage or manipulation of the intestine, and to the treatment of patients subjected to major operations. Although our data are so meager as to be submitted chiefly as a preliminary report, the data on animals as well as humans suggest that cortical extract† does have a favorable effect in the treatment of shock, particularly from the prophylactic standpoint.

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† The cortical extract (eschatin) used in these experiments was kindly furnished by Parke, Davis and Company.

Adrenal cortical extract has been used in shock produced by numerous agents, including that caused by burns. Wilson and associates[4] found the extract to be effective in the treatment of burns, a finding corroborated by Lee and associates.[5] Whether or not the shock of burns is similar to surgical shock cannot be stated conclusively at the present time. Most investigators, including Blalock[6] and others, are of the opinion that the shocking effect of burns is due to a fluid and plasma loss at the surface of the burn and into the burned area (particularly during the first few days following injury), while a few investigators are of the opinion that toxemia plays a significant rôle. Administration of plasma in burns was first advocated by Elman and associates;[7] its efficiency is suggestive proof of the importance of loss of plasma in shock produced by burns, and offers evidence that the shock accompanying burns is similar to or identical with so-called traumatic shock.

Dogs were used in all experiments; ether anesthesia was used throughout. Blood pressure tracings were recorded on a drum by inserting a cannula into the femoral artery. The cortical extract was given intravenously or intramuscularly in doses varying from 0.5 cc. to 2.0 cc. per kilo of body weight. Shock was produced by two methods: (1) hemorrhage, and (2) manipulation of the intestine by squeezing a handful of intestinal loops every two seconds. Although the latter method might be considered somewhat crude, numerous investigators have found it very effective in producing shock, i.e., in causing a drop in blood pressure from 110 to 140 down to 70 or 80 in thirty to fifty minutes. We discovered that one of the most important factors in the consistency of time required for production of shock was the size of the animal. Since the hand squeezing the intestines is the same, the size of the dogs used for controls and active experiments must be relatively the same. We noted uniformly that it required much longer to produce shock by this method in large dogs. When hemorrhage was induced, the rate was always adjusted to 0.5 per cent of body weight every five minutes. The specific gravity of the blood was determined by the falling drop method as utilized by Barbour and Hamilton,[8] Scudder[9] and others.

Series I: Shock Produced by Hemorrhage Alone.   As previously stated, in all experiments bleeding was instituted uniformly at the rate of 0.5 per cent of body weight every five minutes. Only four animals were used in this series, because data in other experiments (Series II and III, and Table 1) relative to the effect of cortin on the tolerance to hemorrhage in shock produced by manipulation of the

intestine were also available. Of the four animals used, hemorrhage alone was induced in two, hemorrhage after a prophylactic dose of cortin in one, and hemorrhage after and during administration of physiologic saline in a fourth. The survival time in these animals was thirty-nine, forty-six and sixty-five minutes, respectively. This datum is too meager to warrant conclusions, but when supported by additional data on hemorrhage as discussed later, leads us to the conclusion that cortin increases slightly the tolerance to hemorrhage, that fluids may be slightly more effective, and that cortin plus electrolytes and 5 per cent glucose are still more effective in increasing tolerance to hemorrhage

Series II: Effect of Cortical Extract (Prophylactic Dose) on Maintenance of Blood Pressure Level during Manipulation Massage of the Intestine. As stated previously, manipulation of the intestine with the hand at stated intervals (every two seconds) is a fairly effective and consistent way of producing shock in dogs. Blood pressure readings during manipulation of the intestine (without cortical extract) are available on five dogs. As shown in Table 1, the average drop in blood pressure after forty minutes of manipulation in animals not

TABLE 1

EFFECT OF CORTICAL EXTRACT ON THE BLOOD PRESSURE FOLLOWING MASSAGE OF INTESTINE AND ON THE SURVIVAL TIME FOLLOWING HEMORRHAGE AT A UNIFORM RATE (0.5 PER CENT OF BODY WEIGHT EVERY FIVE MINUTES) BEGUN NINETY MINUTES AFTER INTESTINAL MASSAGE WAS STARTED

	Drop in Blood Pressure after 40 Min., Mm.	Drop in Blood Pressure after 55 Min., Mm.	Survival Time Following Hemorrhage Begun after 90 Min. Intestinal Massage, Min.
Without cortical extract..........	35.3	38.4	21
With cortical extract.............	19.5	20.0	36.5
Fluids (buf. gluc.) without cortical extract......................	34.0	37.5	27.5
Fluids (buf. gluc.) with cortical extract......................	0	7.5	36.5

Note that there was distinctly less fall in blood pressure when cortical extract was used. Fluids (buffered 5 per cent glucose) alone had very little beneficial effect but fluids with cortical extract prevented shock, although the survival time following hemorrhage was no longer than when cortical extract was given without fluids.

receiving cortical extract, was 35.3 mm., and after fifty-five minutes of manipulation was 38.4 mm. On the other hand, in the animals (3) receiving a prophylactic dose of cortical extract (1 to 1.5 cc. per kilo

of body weight in divided doses eighty and twenty minutes before massage of intestine was begun), the average drop in blood pressure was only 19.5 mm. in forty minutes and 20.0 mm. in fifty-five
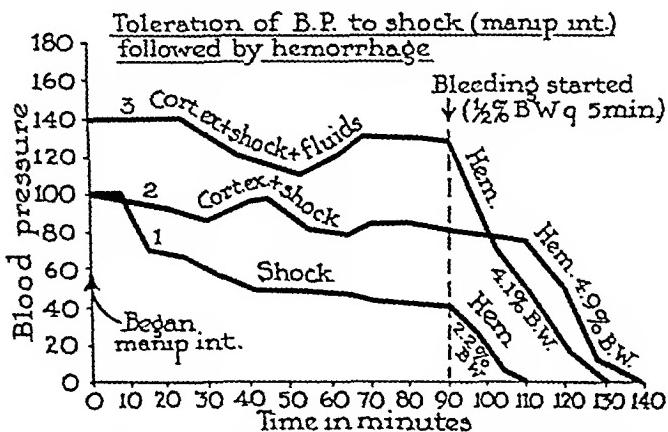
FIG. 1. Curve 1 illustrates the average fall in blood pressure in animals (dogs) submitted to intestinal massage. Note that administration of cortical extract (curve 2), and cortical extract with glucose and electrolytes (curve 3) lessen the degree of fall in blood pressure. When such animals are submitted to bleeding at the end of ninety minutes of intestinal massage, those without cortical extract are killed by much less bleeding, namely, 2.2 per cent of body weight contrasted to 4.1 and 4.9 per cent.

minutes. In this series of animals, bleeding (0.5 per cent of body weight every five minutes) was instituted ninety minutes after massage of intestine was begun. Naturally, the animals that were in shock because of the intestinal massage would not tolerate as much hemorrhage as normal animals. When cortical extract was given prophylactically, before the massage of intestine was begun, bleeding (instituted ninety minutes after the manipulation of intestine was begun) was tolerated much better, there being a survival time of thirty-six and five-tenths minutes to hemorrhage, contrasted to only twenty-one minutes in animals not receiving the extract.

Series III: Effect of Fluids in Prevention of Shock (with and without Cortical Extract). In a pair of animals receiving glucose (50 to 80 cc. per kilo of body weight, buffered with Hartmann's solution), but no cortical extract, manipulation of the intestine produced a drop in blood pressure of 34.0 mm. in forty minutes and 37.5 mm. in fifty-five minutes. (Table 1.) In another pair of animals receiving glucose and electrolytes, but to which cortical extract (1 cc. per kilo of body weight in divided doses about ninety and twenty minutes before manipulation of intestine) had been given, the fall in blood

pressure at forty minutes was 0 and only 7.5 mm. at fifty-five minutes. In other words, shock was almost completely prevented by the fluids and cortical extract, a result indicating even a more
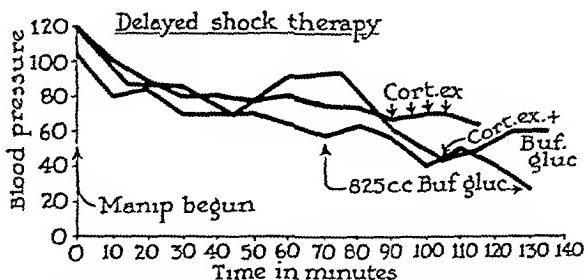
FIG. 2. After shock has been produced neither cortical extract nor glucose and electrolytes will elevate the blood pressure to a significant degree.

beneficial action than obtained with cortical extract alone. The survival time following hemorrhage, begun ninety minutes after institution of intestinal massage in animals given extract and fluids, was only thirty-six and five-tenths minutes, which is identical to that in animals given cortical extract and no fluids. After consideration of this and previous data, it appears that cortical extract is more beneficial in shock (produced by manipulation of intestines) than in hemorrhage.

No experiments were performed with the addition of plasma in the therapy of animals, since it is so well known that plasma is a very effective agent in combating shock. Harkins[10] has splendidly summarized all of the important data on the various features of shock in a recent publication.

Series IV: Effect of Cortical Extract When Given after Shock Is Produced. Shock was produced in a pair of animals by manipulation of the intestines; after the blood pressure had fallen to 60 and 67 mm., respectively, 5 per cent glucose buffered with Hartmann's solution along with cortical extract (up to 2 cc. per kilo of body weight) was given. There was no significant rise in blood pressure following administration of cortical extract (Fig. 2); in other dogs, administration of glucose and electrolytes alone likewise seemed to have no beneficial effect in correcting the shock. These findings support the belief that administration of glucose and electrolytes (particularly glucose alone) in the absence of plasma, as expressed by Blalock[11] and many others, may "wash out" plasma and electrolytes from the blood stream.

Specific Gravity of Blood during Hemorrhage and Shock. Conforming to the experience of Scudder[9] and others, we found that hemorrhage produced a decrease in specific gravity of the blood (as
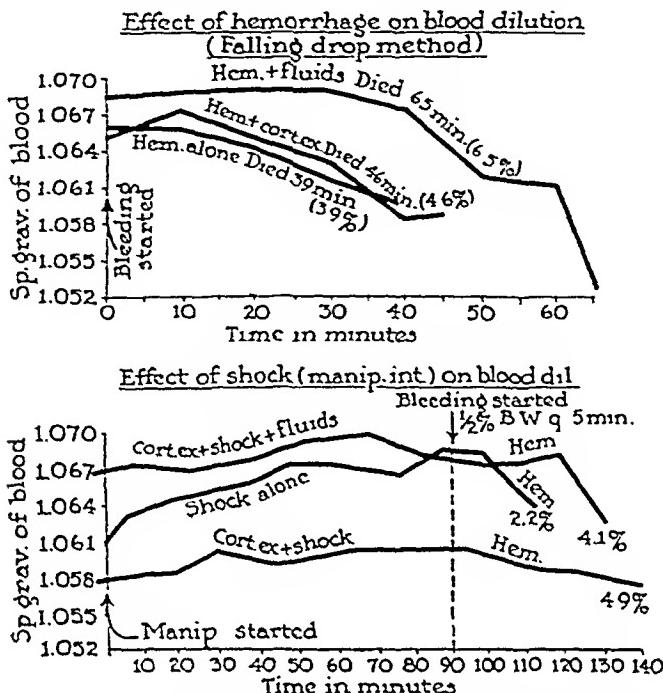
FIG. 3. The specific gravity of the blood, as determined by the falling drop method, decreases during hemorrhage (top graph), and increases during shock (lower graph). Note that the increase during shock (produced by intestinal massage) is slightly less when cortical extract is given to the animals an hour or two before the experiment is started.

determined by the falling drop method) and that shock produced an increase in specific gravity. (Fig. 3.) If hemorrhage is added to shock (in the late stages as noted in Figure 3), a sharp decrease in specific gravity is noted. When cortical extract is given as shock is being produced, there is a definite but slight tendency to maintain the specific gravity at a constant level, revealing little or no increase in specific gravity.

Effect of Cortical Extract on Shock in Human Beings. In an effort to determine the efficacy of cortical extract in the treatment of shock in a human being two methods of therapy were utilized: (1) patients representing isolated cases of shock (which fortunately in modern days are relatively rare) were treated with intramuscular and intravenous administration of cortical extract in doses up to 20 cc. per patient: and (2) extract was given an hour or two before opera-

tion, attempting to decrease shock manifestations. Although it happens that a very rapid recovery was obtained on every occasion in which the extract was used after shock was present, this fact does
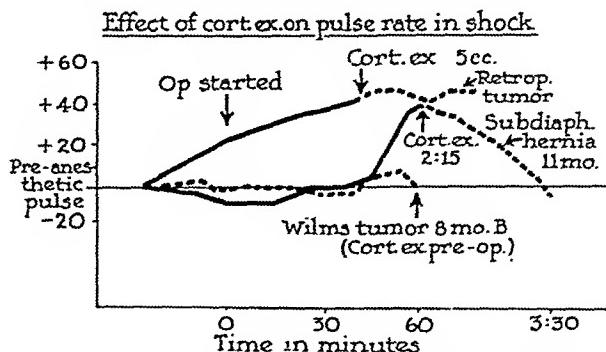
FIG. 4. The three curves represent the pulse rate in an adult during resection of a retroperitoneal tumor; in an eight-month's old infant, during nephrectomy for a large Wilms' tumor; and in a child submitted to repair of a subdiaphragmatic hernia (right side) in which a lot of manipulation, or retraction of the liver was necessary during repair. The adult having resection of the retro-peritoneal tumor did not receive cortical extract until early signs of shock (rise of 40 in pulse rate) were present. The child having repair of the hernia showed moderate shock (pulse 180) developing during the last few minutes of the operation, but within eight-five minutes after cortical extract was given the pulse rate had receded to normal. As stated in the text, isolated cases of this type cannot be used as very significant evidence because we have no knowledge of the possible reaction without cortical extract.

not prove the efficacy of the drug, since we have no way of disproving the possibility that recovery would have been just as rapid without the cortical extract. Figure 4 illustrates three cases which revealed what might be considered a favorable effect on shock. In one patient, however, in whom a retroperitoneal tumor was being resected, the pulse rate which had risen to about 140, was not reduced although no further evidence of shock was manifested. Blood was not given to this patient at this time although fluids were administered. It is doubtful whether or not even a large series of such cases would yield a conclusive answer. Although our experiences with treatment in the presence of shock were of the favorable type, the beneficial effect was much more pronounced when the extract was given prophylactically.

In an effort to obtain data on the prevention of shock in major operations, the extract was given to patients having major opera-

tions of unusual duration and severity. In a series of fifteen such cases, consisting of four gastrectomies, three resections of the rectum, two gastroenterostomies, two resections of the colon, etc.,
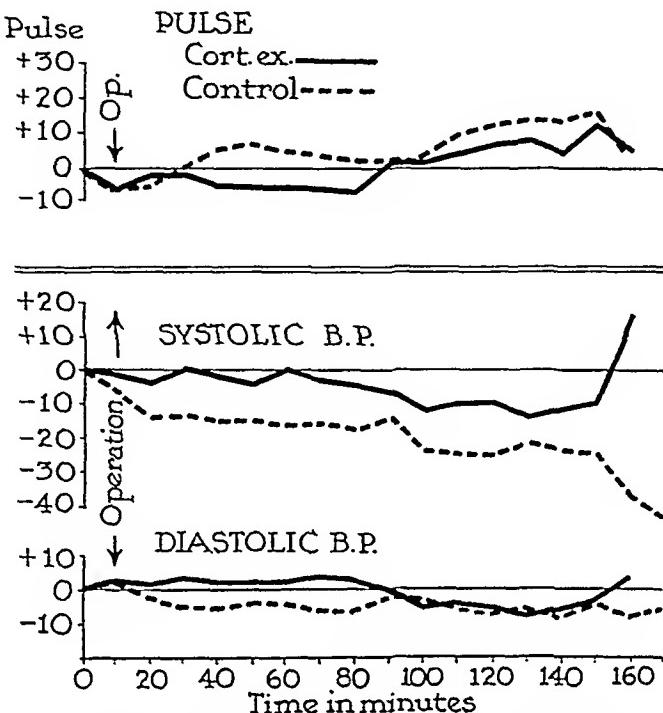
FIG. 5. As described in the text the average pulse rate and blood pressure were determined in fifteen major operations of unusual magnitude and duration, and in which cortical extract was given preoperatively (solid lines). A control series of fifteen identical operations of equal duration, but not receiving cortical extract, was studied (broken lines). Comparison reveals that there was more elevation of pulse rate, and a greater drop in blood pressure in patients not receiving extract. The diastolic pressure revealed only slight change.

we gave the drug in divided doses in amounts between 6 and 10 cc. one and a half hours and thirty minutes before operation. We went through the hospital records and found an equal number of gastrectomies, resections of the rectum, etc., with a similar type of operation, lasting the same length of time, to whom cortical extract was not given, but in whom the remaining therapy was similar. We averaged the pulse rate, and the systolic and diastolic pressure in the two series of cases. Figure 5 illustrates the differences encountered in the pulse rate and blood pressure levels in the two series. The illustration reveals a pulse rate averaging eight beats per minute lower throughout the operation in patients to whom cortical extract

was given. The systolic blood pressure averaged 12 mm. lower in patients not receiving cortical extract. In other words, cortical extract appeared definitely to maintain a slower pulse rate and a systolic blood pressure nearer the normal level. The differences in the level of the diastolic blood pressure in the two series was probably too slight to be of any significance. However, there was a slight tendency toward a lower diastolic blood pressure in the control patients not receiving cortical extract.

SUMMARY

In an effort to determine the efficacy of cortical extract in the prophylaxis and the treatment of shock, the extract was given to animals subjected to shocking procedures and to human beings having major operations of a magnitude apt to produce shock. In animals, shock was produced by hemorrhage and by massage of the intestine with the animal under ether anesthesia. In experimental shock produced by hemorrhage cortical extract exerted a definite but slight tendency to decrease the severity of shock, particularly when the extract was given with fluids (glucose and electrolytes). Fluids alone, i.e., without cortical extract, did not significantly prevent the fall in blood pressure although the actual survival time following hemorrhage was increased.

When cortical extract was given an hour or two before institution of intestinal massage (to produce shock), the average drop in systolic blood pressure after forty minutes of massage was only 19.5 mm., contrasted with 35.3 mm. in animals not receiving extract prophylactically. Moreover, when hemorrhage of a constant rate was instituted ninety minutes after intestinal massage was begun, there was a survival time of thirty-six and five-tenths minutes in animals receiving cortical extract, contrasted with a survival time of only twenty-one minutes in animals not receiving cortical extract. When glucose and electrolytes were given in addition to extract, the effect was still more prominent, there being no drop in blood pressure after forty minutes of massage and an average of only 7.5 mm. after fifty-five minutes of massage. In other words, the beneficial effect of cortical extract and fluids (glucose and electrolytes) in prevention of shock was comparable to that which might be expected from plasma. When extract was given after shock had already been produced in animals very little beneficial effect could be demonstrated; there was little or no rise in blood pressure although further drop was slightly delayed.

Falling drop determinations showed an increase in specific gravity of blood in shock, and a decrease after hemorrhage as reported by others. Cortical extract showed a definite but slight tendency to counteract the increase in specific gravity produced by shock.

In human beings the use of cortical extract in the presence of shock was limited to a few cases due to the relative infrequency of shock, but in every instance the effect appeared to be beneficial.

In order to determine whether or not cortical extract would exert a favorable influence in prevention of shock, the average pulse rate and blood pressure was computed in a series of fifteen patients receiving cortical extract prophylactically, and upon whom major operations of unusual duration and severity were performed. From the hospital records an equal number of operations (in which no cortical extract was given), with equal number of types and duration, were obtained and the average pulse rate and blood pressure likewise determined. In the patients receiving cortical extract prophylactically, the pulse rate averaged eight beats per minute slower, and the systolic blood pressure 12 mm. higher than in the patients not receiving extract. This suggests that the cortical extract tends to minimize the changes which might be interpreted as being changes preliminary to the development of shock.

Observations on animals as well as patients showed that the extract was much more effective when given prophylactically, than when given after shock was already produced.

REFERENCES

1. SWINGLE, W. W., PFIFFNER, J. J., VARS, H. M. and PARKINS, W. W. The effect of hemorrhage on the normal and adrenalectomized dog. *Am. J. Physiol.*, 107: 259, 1934; SWINGLE, W. W., PARKINS, W. M., TAYLOR, A. R. and HAYS, H. W. Direct effect of adrenal cortical hormone upon blood pressure in shock induced by intestinal manipulation. *Proc. Soc. Exper. Biol. & Med.*, 37: 601, 1937.

2. SELYE, H., DOSNE, C., BASSETT, L. and WHITTAKER, J. On the therapeutic value of adrenal cortical hormones in traumatic shock and allied conditions. *Canad. M. A. J.*, 43: 1, 1940.

3. WEIL, P. G., ROSE, B. and BROWNE, J. S. L. The reduction of mortality from experimental traumatic shock with adrenal cortical substances. *Canad. M. A. J.*, 43: 8, 1940.

4. WILSON, W. C., ROWLEY, G. D. and GRAY, N. A. Acute toxemia of burns, extract of suprarenal cortex in treatment. *Lancet*, 1: 1400, 1936; WILSON, W. C. and STEWART C. P. Changes in blood chemistry after burning injuries and in other grave surgical conditions; with some reference to treatment by desoxycorticosterone acetate. *Edinburgh M. J.*, 46: 153, 1939.

5. RHOADS, J. E., WOLFF, W. A. and LEE, W. E. The use of adrenal cortical extract in the treatment of traumatic shock of burns. *Ann. Surg.*, 113: 955, 1941.

6. BLALOCK, ALFRED. Experimental shock. VII. The importance of the local loss of fluid in the production of the low blood pressure after burns. *Arch. Surg.*, 22: 610, 1931.

7. WEINER, D. O., ROWLETTE, A. P. and ELMAN, ROBERT. Significance of loss of serum protein in therapy of severe burns. *Proc. Soc. Exper. Biol. & Med.*, 34: 484, 1936; COLE, W. H. and ELMAN, ROBERT. Textbook of General Surgery. 1st ed. New York, 1936. D. Appleton-Century Co. ELMAN, ROBERT. The therapeutic significance of plasma protein replacement in severe burns. *J. A. M. A.*, 116: 213, 1941.

8. BARBOUR, H. G. and HAMILTON, W. F. The falling drop method for determining specific gravity. *J. Biol. Chem.*, 69: 625, 1926.

9. SCUDDER, JOHN. Shock: Blood Studies as a Guide to Therapy. Philadelphia, 1940. J. B. Lippincott Co.

10. HARKINS, H. N. Recent advances in the study and management of traumatic shock. *Surgery*, 9: 231, 1941.

11. BLALOCK, ALFRED. Principles of Surgical Care, Shock and Other Problems. St. Louis, 1940. C. V. Mosby Co.

DISCUSSION

FRED W. BANCROFT (New York City): I thought it might be of interest, in addition to Dr. Cole's paper, to review briefly first what happened to adrenalectomized animals; and, secondly, to give some definite indications for the use of cortical extract.

If I may, I should like to read very briefly from an article by Dr. Edward C. Kendall, of Rochester, Minnesota, which appeared in the *Journal of the American Medical Association* recently:

"When the adrenal glands are removed from laboratory animals, symptoms of deficiency develop which may be summarized as follows: The first notable change is usually a loss of appetite, which is soon followed by nausea, vomiting, increased peristalsis, and eventually bloody diarrhea. Associated with these changes are profound weakness of the muscles and a listless stupor, or, in some animals, restlessness and marked salivation, with clonic movements and general convulsions similar to those observed in hypoglycemia induced by insulin. There is a gradual decrease in body temperature, and a decrease in the basal metabolism rate.

"Continuance of the state of adrenal deficiency is invariably associated with a decrease in blood pressure to the death level, an increase in the hematocrat reading, and a progressive decrease in the volume of the circulating blood. Soon after removal of the adrenal glands there is a marked and continuous increase in the concentrations of non-protein nitrogen and potassium and a decrease in the concentration of sodium and chloride in the blood serum."

In shock there is a pooling of the plasma in the tissue spaces with hemo-concentration. There is also present a spasm of the arterioles and smaller veins. Our purposes then are, first, to relieve the spasm of the terminal arteries, which can be done by administering sodium, and, second, if we consider the tissue space as a sponge, to use a method to squeeze the sponge

in order to get the plasma back into circulation. If we cannot actually squeeze the sponge, we should at least attempt by medication to decrease the permeability of the capillaries. (Fig. 6.)
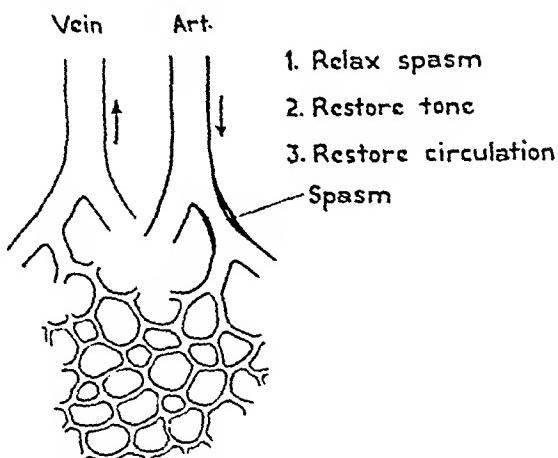
FIG. 6. Diagrammatic sketch of the capillary spaces.

It has been shown by Walter Estell Lee that in very diffuse burns, if cortin is given less plasma has to be given the patient in order to overcome the hyperproteinemia. Also, if cortin is given early the specific gravity of the plasma is increased and stays at an even level. If plasma alone is given, there is a temporary rise and then a fall in the specific gravity of the plasma. If plasma and cortin are given together, we then have a curve that rises and stays up. Also we know that the sodium will decrease our arterial spasm so that it would seem that hypertonic saline given at the same time would help, first, to relieve the spasm, and the plasma and cortin will help to squeeze the sponge and diminish the vascular permeability.

My own experience has been as follows: In a large intestinal resection, a woman's blood pressure dropped to 80/40. Our blood bank had failed us. We tried giving gum acacia, which did not bring the blood pressure up. Within twenty minutes after the administration of cortin, her blood pressure had risen to 110/80. It dropped to 105, but stayed at that level.

In another case, an abdominal peritoneal resection, the night following the morning of operation her blood pressure dropped to 80/40. Glucose did not have any effect. We were not able to get transfusion at that minute. On administration of escotin her blood pressure arose to 110.

So, as a result of my own experience, I am convinced there is a very definite need for cortical hormone in preventing and relieving delayed postoperative shock.

I have enjoyed listening to Dr. Cole's paper and am thoroughly in accord with all he has presented.

J. S. L. BROWNE (Montreal, Quebec): I have been extremely interested in this paper and in Dr. Bancroft's discussion. As I mentioned, there is a

reasonably good rationale behind the use of cortical substances in the condition of shock.

The idea of using adrenal cortical extracts for this purpose has been going on for quite a considerable period of time, gradually increasing in definiteness. It perhaps began with Swingle, who suggested as far back as 1931, I think, that the symptoms of adrenal insufficiency and those of shock were rather similar.

Cortical extracts were used clinically by Reade some time ago. He believed that he obtained an improved postoperative course in his patients after the use of cortical extracts, even in those in whom no shock occurred. Perla and his collaborators obtained good results, using desoxycorticosterone acetate and sodium chloride in preventing shock.

Dr. Cole asked me to discuss the question of the difference between desoxycorticosterone acetate and cortical extracts. Our experience has been limited, as I think I said, to the use of the intestinal manipulation method of inducing shock in rabbits. The difference has also been studied in rats by Dr. H. Selye and his collaborators. Weil, Rose and Browne found in the rabbit that the mortality could be reduced from approxmately 60 to 19 per cent using both cortical extract and desoxycortieosterone acetate together, but only to 42 per cent if desoxycorticosterone acetate was used alone. The latter is not a statistically significant reduction in mortality. Selye, Dosne and Bassett found desoxycorticosterone acetate to be ineffective in the rat.

As I pointed out, these substances were used prior to the trauma. In other words, it was a prevention rather than a cure.

I think it is very important for us to consider whether cortin will do anything which blood, serum plasma or other blood substitutes will not do. I also think it is important to consider the question of the amounts which have to be used. I would like to ask Dr. Cole what were the amounts he used.

I would also emphasize that although at the present time the cortical extracts are of greater uniformity than they used to be, still the cortical extracts prepared by various companies may not always contain the same kind or amount of cortical substances; and since it does appear, as far as certain types of shock are concerned, that the substances of the corticosterone type are more effective, this may be of importance in the results obtained.

Our own experience with patients has, I may say, not been dramatically convincing. It is extremely difficult, as you well know, to give cortin to a patient in shock without giving him the other types of therapy ordinarily recognized. It is, in fact, impossible. And when one obtains a result it is often difficult to evaluate the relative merits of the cortical extract, as compared with the results obtained when normal saline plasma, blood, etc., are used.

I think it is true to say that our most encouraging results (we have had only one or two cases) have been in infants, in which we have used 25 to 50 cc. of Wilson's cortical extract. That makes one wonder whether it is possible, as it has been so often in the past, that the doubts which have arisen regarding this method of therapy are due to the fact that our dosage level is inadequate, and that we are in the same stage with cortical extract in this therapy that we were with many other hormones in the days when they were given in perhaps a tenth of the amount really necessary, and occasionally, in a very sensitive patient, good results were obtained.

I think, too, that in certain cases, relative cortical deficiency may be the limiting factor in the development of shock. There are possibly some people who are unable to increase the amount of cortical substances put out by their adrenal when they are put to the stress of operation or trauma; or, some patients may already be putting out their maximum if they have had prolonged infection or are aged, etc. In them, one might get definite results with cortical extracts.

In the normal adult male, we will say, who is traumatized, it is questionable whether one can give an amount equal to that produced by the patient's own adrenal cortex. We know in animals that the amounts of cortical substances necessary to produce the effect in normal animals are very much greater than those necessary to make the proper restoration in the adrenalectomized animal.

It seems perfectly clear in the case of Addison's disease that one can get dramatic improvement in resistance to trauma by the use of cortical extracts, but it is much more difficult to prove it for the normal person. So while I agree there are a good many indications in which perhaps adrenal cortical extracts are beneficial, I am not sure but that we are going to have, in fact, I am sure we are going to have great controversy about it, and I wonder whether it may be because we are not using sufficient dosages.

We had a case of intracranial operation for trigeminal neuralgia. The patient went into shock with falling blood pressure. At one time the blood pressure was unobtainable. At this point, 25 cc. cortical (Wilson's) extract was given intravenously, and the blood pressure did reappear within fifteen minutes. Blood transfusion had been given continuously up to this point. It is very difficult to evaluate this case because blood and saline had also been given. However, there is a slight rise in blood pressure associated with the dose of cortical extract but I do not think that it is very significant.

In a second case a small amount (50 cc.) of concentrated serum was given. This was one of the early preparations. It produced a more severe shock than I have ever seen. It was matched with the patient's blood. This patient continued throughout about twelve hours to have a blood pressure below 80, and at various points 25 cc. of cortical extract was given with perhaps slight effect. But 500 cc. of blood was given some hours later with a dramatic rise in blood pressure which occurred immediately after. Here then

we have blood giving a very much better effect than cortical extract in the doses used.

A third case was one in which again one may say perhaps some slight effect was obtained from cortical extract. Ten cc. was given intravenously but no saline. At this point there was a sharp rise in blood pressure. This is about the only case in which one can say there was a definite effect.

In a fourth case with falling blood pressure 20 cc. of cortical extract was given and a small amount of saline with it, with some rise in blood pressure. But, as you all know, in this type of case the blood pressure is likely to rise spontaneously, and one questions just how much the treatment had to do with it.

I admit that the studies on these cases have not been as well planned as they might have been from the experimental point of view. This is sometimes difficult to do in cases of shock in which rapid and multiple therapy is, of necessity, often undertaken. I think that it is possible, quite probable in fact, that cortical extracts will be beneficial. However, I think that our doses are probably too low at the present time.

J. B. COLLIP (Montreal, Quebec): I am sure, due to the lateness of the hour, you do not want me to give a lecture today, but there are a few things I might say of interest in relation to shock.

This age-old subject has come very much to the fore on account of the war, and laboratories engaged in other pursuits are now in some cases turning all their attention to work upon this and closely allied topics. Work which is being done under government auspices on this subject cannot be talked about by the workers until their results have been reviewed by a sub-committee of publications.

There are a number of generalities, upon which I may speak. The question as to whether suprarenal products will be of value is certainly very much to the fore, and the work reported by the speaker today would indicate that cortin (cortical extracts containing many hormones) has got a place in the treatment of shock.

I think that one of the finest pieces of work which has been published on this subject is that by Dr. Swingle, of Princeton. Dr. Swingle had the courage to use his very precious adrenalectomized dogs. These animals are particularly susceptible to various procedures which produce shock, procedures which have to be applied very, very vigorously in normal animals, such as injury to muscle or injury to intestines.

Swingle pointed out that it is only necessary to tap adrenalectomized dogs' muscles very lightly for a short period of time to send them into profound shock. If the dog is not treated, the blood pressure falls steadily, and the animal dies in a few hours, so he has an ideal preparation to test various forms of therapy.

He showed very conclusively that if he gave, starting the night before, two injections, I think, at four hours apart, 5 mg. of desoxycorticosterone

in oil, followed by another injection in the morning on which the experiment was performed, he could absolutely counteract the effect of muscle trauma producing shock in these animals.

Cortical extract, however, is much more soluble and when given as a solution he found by injecting it when the blood pressure was as low as 40, that he could almost invariably restore the animal to normal.

When, however, he proceeded to do much the same type of experiment, but using intestinal trauma, (gentle stripping of the intestine) the animals so treated went into profound shock and died within a few hours. He got absolutely no recovery when he used desoxycorticosterone, but cortical extract gave protection. Thus he did show a remarkable distinction (at least under the conditions with which he was working) between the effect of desoxycorticosterone in restoring normalcy after muscle trauma, whereas it was perfectly useless in counteracting shock produced by stripping the intestines.

As Kendall has pointed out, there are something like eight individual steroids which have been isolated from the suprarenal cortex, all of which are presumably present in cortical extract, but in varying degrees. It is even possible that some of these cortical steroids are definitely antagonistic to each other. There is a small amount of desoxycorticosterone in suprarenal cortex which has been extracted and identified and which is presumably present in all, but corticosterone and Kendall's Compound E, apparently are the things which we want. Desoxycorticosterone has its use but it has its limitations. Undoubtedly, blood substitutes will have their place in the treatment of shock looking at it from the laboratory angle.

Recently, some of the work going on in my laboratory has been released for publication, and if you care to listen to Dr. Noble for two or three minutes, he might tell you something about it.

R. L. NOBLE (Montreal, Quebec): It is interesting to note that the criteria used in the effectiveness of cortical extract in the treatment of shock as related to the vascular system, the cardiovascular system, such as the pulse rate. As I mentioned the other day, it seems that the fundamental mechanism which goes wrong in shock is the loss of plasma into the tissues, and if it were possible to correct this fault, an effective treatment of shock might be available.

We have some experimental results using stimulation of the adrenal glands and studying the effects on hemoconcentration which tend to show that the adrenal cortex has an effect in aiding the return of fluid from the tissues, back into the blood stream.

In these experiments we were using histamine, which is a chemical substance and has an advantage that it can be used quantitatively. We were not using it because we believe that it is the causative factor in shock, but following this injection a normal rat shows hemoconcentration in the first half-hour of 30 or 40 per cent. This rapidly returns to normal in approx-

imately six hours. If it is used on an adrenalectomized animal, the degree of hemoconcentration is slightly greater; but the blood remains concentrated for six hours and even up to twenty-four hours, showing the tissues apparently hold onto the plasma in the absence of the adrenal cortical hormone. But after treating these animals with a satisfactory extract, it is possible to have them behave as normal animals; that is to say, they show hemoconcentration initially for thirty minutes, and then the plasma returns rapidly to the blood stream, so the blood volume returns to normal.

This is quite a definite indication, I think, of the value of adrenal cortex in the mechanism of this kind. However, as pointed out before, the normal animal is a very definite proposition. We have not been able to give a normal animal any sort of treatment and prevent this hemoconcentration from occurring, although it is possible to restore the adrenalectomized or hypophysectomized animal so it behaves like a normal animal.

WARREN H. COLE (closing): I would first like to thank the discussers. Dr. Browne asked a question regarding dosage; we used ½ of 1 cc. per kilo of body weight in animals, and at times repeated it in an hour or so depending on the type of experiment being performed. In adults we did not give such large doses, varying the amount from 4 to 20 cc. I am convinced the various products obtained would vary tremendously in their active principles, but I believe that we were fortunate in having a fairly potent product. We used 4 to 10 cc. for a prophylactic dose and up to 20 cc. for active treatment of shock. As much as 60 cc. or more may be given in twenty-four hours, since the extract does not appear to be toxic even in such large doses.

RÉSUMÉS OF CLINICS AT MONTREAL GENERAL AND ROYAL VICTORIA HOSPITALS

1. *Acromioclavicular Dislocation (Dr. D. W. Ramsey).* Movement at the acromioclavicular joint is a necessity to the well functioning shoulder. These movements are of two kinds: (1) A gliding motion of the articular end of the clavicle on the acromion, and (2) rotation of the scapula on the clavicle. Repair of the dislocation then aims at restoration of anatomical position with maintenance of function.

The acromioclavicular joint is a true joint having articular cartilages with or without an articular disc and a capsule. Above the capsule is the acromioclavicular ligament. The joint is greatly strengthened by the coracoclavicular ligament which is made up of two parts, viz., the conoid and trapezoid ligaments.

Dislocation is brought about most commonly by a fall on the shoulder while the body is in motion, or by a weight falling on the tip of the shoulder. This causes a twisting motion of the scapula in such a manner that the axis of rotation lies between the acromion and the coracoid process. The acromion is pulled downward and the coracoid process impinges on the clavicle, pushing it upward so that the lateral end of the clavicle rides over the acromion. This displacement is aided by the slope of the joint, the articular surface of the clavicle facing downward and outward.

Two degrees of dislocation are described: (1) A subluxation as a result of tearing of the acromioclavicular ligament and (2) a complete dislocation when all the ligaments are torn.

On March 3, 1941, a man fell with a ladder to the floor, landing on his right shoulder. He was brought to our surgical out-patient department where examination showed that he had limitation of movement at the shoulder due to extreme pain. The tip of the shoulder was depressed and the outer end of the clavicle was quite prominent. Tenderness was marked in the region of the acromioclavicular joint.

An x-ray was taken and showed the dislocation to be quite complete. Strapping was applied but this proved unsatisfactory and he was admitted to the ward on March 8.

After a two-day skin preparation with E.A. plus iodine, the joint was exposed by an S-shaped incision over the front of the shoulder. It might be mentioned here that as soon as the anesthetic was given the dislocation could easily be reduced by pushing upward on the elbow. Two drill holes were then made through each of the adjoining bony parts of the joint. A wire mattress suture was applied through the drill holes in such a manner that the wire bridged the joint underneath the capsule but not above. The capsule itself was repaired by No. 2 chromic catgut. The operation was completed by applying elastoplast strapping after the method of Watson-Jones.

X-ray postoperatively showed complete reduction. The elastoplast support was maintained for five weeks. After nine weeks passive movement was fairly good, but active movements up to that time have not been fully regained. It might be added that he is a compensation case.

2. *Prevention of Slip in Spiral Fractures of Both Bones of the Leg* (Dr. L. H. McKim, M.D.). The injury specifically referred to is the very common spiral fracture at or about the junction of the lower and middle thirds of the tibia. The mechanism of production is of the rotation or torsion type. The line of fracture runs obliquely upward and outward and, in the anteroposterior view, usually points to the fibular fracture in the upper third of that bone. (Fig. 1.)

It is not the intention of the author to discuss the advisability of treatment of this injury by the application of plaster of Paris cast nor to compare the results so obtained with those by other more complicated methods. Under certain circumstances, plaster fixation is almost the only available form of treatment and may be the method of choice for various reasons.

Every surgeon, who has treated this injury, has observed the tendency of the lower fragment to slip upward and usually outward. This deformity tends to occur as soon as the cast becomes even slightly loose.

Previous to the introduction of our present method, we were able to prevent slipping only by early (and frequent) changes of the cast under anesthesia. We have found that the method at present in use not only reduces the number of reapplications of the cast but also adds very materially to the comfort of the patient by relieving the pain so often complained of in the region of the ankle.

In order to clarify the principles on which this treatment is based, it may be well to make certain general statements with which most surgeons will agree. These are: (1) If plaster fixation is to be made use of, this injury must be treated with a close fitting cast extending as

far up the thigh as possible. (2) Displacement tends to occur as soon
as the cast begins to become loose. (3) Casts become loose (a) from
lessening of primary swelling and edema, (b) from atrophy of the
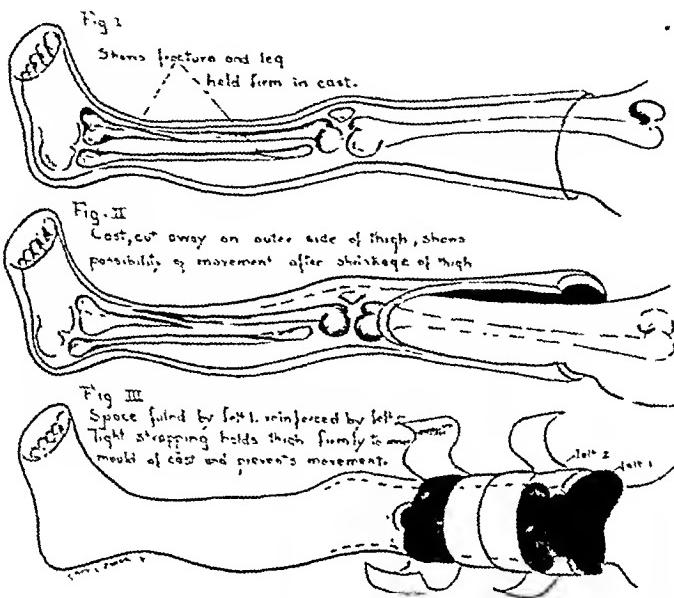
FIG. 1. Diagrammatic sketch of mechanism of displacement
and method of correction.

muscles enclosed by the cast. (4) From this it follows that the
greatest degree of loosening occurs in the thigh when muscular
atrophy is very rapid. The calf muscles, by their shrinkage, also
cause an appreciable space soon to become apparent between the soft
tissue and the cast in the lower leg region. (5) The presence of the
many superficial bony prominences about the knee makes this the
region where the *least* loosening occurs.

A consideration of the above mentioned items will give an instant
appreciation of the factors concerned in the displacement of the tibial
fragments (for practical purposes, the fibula may be disregarded since
the fracture is in the upper third and is of little importance, apart
from the extremely rare complication of involvement of the peroneal
nerve in the callus). We have thus the following condition of affairs:
(1) The upper tibial fragment enclosed in a more or less loose cast due
to shrinkage of calf muscles; (2) the knee region, where very little
loosening occurs, forming a relatively firm point of leverage; (3) the
femur, forming the long arm of a lever, transmits forceful movements
to the upper tibial fragment.

The direction of possible movements of the upper tibial fragment
should be considered. It will be immediately understood that, if the

above mentioned theory of the knee region acting as the point of leverage is admitted, any lateral movement of the femur will cause the lower end of the upper tibial fragment to be displaced medially.

FIG. 2.   FIG. 3.   FIG. 4.

FIG. 2. Cast cut away on outer side above knee. Note normal line of weight bearing, anterior superior spine, middle of patella and second metatarsal bone.

FIG. 3. Leg abducted. Cast allowed to fall away from inner side of thigh. Upper two points of line of weight bearing same as in Figure 2. Note point of fracture now three inches external to line and a possibility of medial displacement of lower end of upper tibial fragment.

FIG. 4. Felt pads applied and thigh fixed. Note re-establishment of line of weight bearing.

The opposite movement, medial displacement of the femur, will, of course, cause the upper fragment of the tibia to be displaced laterally. Real displacement in this direction is impossible since the slope of the fractured surfaces could only be the more closely approximated by such a maneuver. It follows, therefore, that the secret of keeping the fractured surfaces in close contact lies simply in keeping the femur as close as possible to the medial wall of the cast. This explains why the simple method adapted for the prevention of lateral movements is so effective.

It may be noted that the leverage movements described operate only in a lateral or medial direction. The mechanism does not apply as regards anterior and posterior movements because of the natural hinge of the knee joint.

The method consists in the incorporation of a firm plaster mould in the medial wall of the cast. This mold must be of considerable strength and should extend from the foot to the upper third of the

thigh. As soon as any shrinkage of the thigh muscles occurs, usually in five to seven days, the outer or lateral part of the cast, from the knee upward, is cut away and the thigh firmly fixed to the thick medial aspect of the cast by applying thick pads of felt to the outer side of the thigh and fixing them in place with circular straps of adhesive. These straps hold the thigh firmly against the thick medial wall of the cast and must be readjusted at short intervals as greater shrinkage of the muscles occurs. (Figs. 2, 3, and 4.)

There is nothing new in the principle involved in this method. All surgeons, who have had extensive experience in the use of the Thomas splint, know that the secret of control of fragments (either in the upper or lower leg) lies in keeping the inner side of the ring closely approximated to the inner side of the thigh. The inner bar of the Thomas splint more or less corresponds to and parallels the direction of the leg bones when the splint is properly used. This is not true of the *outer* bar of the splint owing to the various sizes of the ring. It is often advisable to use slight lateral traction on the upper end of the splint by means of a pulley at the side of the bed to maintain close contact between the thigh and the inner part of the ring. The similarity of the principle involved is apparent.

3. *Fracture Dislocation of the Tarsal Navicular (Dr. R. R. Fitzgerald).*

Case Report: The patient, a miner, thirty-one years old, fell from a scaffold a distance of about sixty feet, lighting on a pile of loose rock. The principal injury consisted of a comminuted fracture of the left tarsal navicular (scaphoid) bone, with dorsal displacement of the wedge-shaped major fragment. After manual traction and plantar flexion, the bone could be pressed down into its bed, but as soon as firm pressure was released, it again sprang up on to the dorsum of the foot. This largest portion of the bone was wedge-shaped, with an intact dorsum, and a fragmented plantar part, where the strong attachment of the tibial posticus and long and short plantar ligaments anchored the broken pieces deep in the navicular space.

The problem was to open the navicular bed by distraction, and to hold it open by mechanical fixation for the period of ten weeks or so that are necessary for the replaced fragments of the navicular to solidify into a bony mass that can again take its place in the arch of the foot.

In this patient the traction was obtained by five stainless steel wires, one passed through the soft tissues of the tip of each toe and wound over a steel bar. The counter traction came from a 5 mm. steel nail driven through the calcaneus. To overcome the pull of the muscles, a distracting force of fourteen pounds was used in the long axis of the foot. The pieces of the bone were then gently pressed into the open space.

A second 5 mm. nail was then driven through the bases of the meta-tarsals, and the foot and leg embedded in a nonpadded plaster walking boot. When the plaster had set, the wires were removed from the toes and the walking heel adjusted. The patient began to walk on the third day, and the check films show the reassembled bone sitting in its natural place between the talus and cuneiforms. He will be instructed to walk as much as possible to discourage demineralization of the bones, and in ten weeks the nails and plaster will be removed.

This case is discussed because of its rarity, and because the method here described has apparently been successful.

4. *Intertrochanteric Osteotomy for Nonunion of Fracture of the Neck of the Femur (Dr. J. A. Nutter).* Fracture of the neck of the femur frequently yields to various pegging or nailing operations with the production of bony union. Even after months of delayed or even nonunion, such treatment may be successful. Unfortunately, the production of bony union is by no means a guarantee of good function and freedom from pain. Months or even years after the original fracture the development of a dead head (with softening and deformity) or of painful osteo-arthritis may not uncommonly occur. An operation which, it is thought, may be followed less frequently by these complications was demonstrated. This operation was inter-trochanteric osteotomy just above the level of the lesser trochanter, following which the upper end of the femoral shaft is pushed inward to lie snugly beneath the head of the femur, thus providing end bear-ing. The osteotomy is obliquely downward and outward to encourage union of the great trochanter. In some cases the non-union neck fracture is healed, but in any case the shaft and trochanter together form a crutch under the head which gives good weight bearing, and may even form a new joint.

A very heavy woman (about 220 pounds, age fifty-nine) was shown who had had such an operation a year previously, two and one-half years after hip fracture, without any union. This patient walked around very comfortably with a stick, suffering very little pain and doing her own housework. Movement was excellent and shortening negligible. This oper-ation, developed particularly by McMurray, of Liverpool, has proved so successful in cases of non-union that it is now being used in fresh hip fractures, particularly those near the acetabulum. An illustrative case was shown (woman age sixty-one) operated upon last August, now walking with good movement and very little disability in spite of non-union of her fracture.

It is to be noticed that such an operation requires very little apparatus and can be done in twenty to thirty minutes. A cast should be worn for a few months in a position of slight hip abduction and flexion and slight knee flexion.

5. *Abstracts of Discussions Relating to Traumatic Shock and Storage of Blood (Dr. J. B. Collip).* The discussion was opened by Dr. J. B. Collip who outlined briefly the work of the National Research Council, with particular reference to the support of medical research relating to problems arising as a result of the war. He indicated also that a very close liason had been established between the Associate Committee on Medical Research of the National Research Council of Canada and the various Committees of the National Research Council in Washington dealing with medical matters.

The discussion was continued by Dr. R. L. Noble and Dr. O. F. Denstedt.

Shock. Abstract of Discussion by Dr. R. L. Noble: Some of the difficulties in evaluating shock in clinical cases were discussed. The grouping of cases of comparable severity for determining therapeutic procedures is difficult and complications such as hemorrhage, infection and intravenous administration of fluid may be encountered. Many difficulties are also present in attempting to produce a quantitative degree of shock experimentally. Most methods of applying direct trauma are associated with hemorrhage and anesthesia and are not quantitative. The experimental findings which have been used as an indication of shock are often open to criticism. Blood pressure alterations may be influenced by anesthesia. Blood volume measurements by the dye method are affected by loss of dye through the capillaries in a shocked animal. Hemoglobin values are influenced by hemorrhage. Some biochemical changes may be misleading. The actual death of the animal is stressed as the most accurate end point in experimentally induced shock. The factors suggested for the cause of death in shock were reviewed and the different pictures following hemorrhage and shock were contrasted. It was suggested that the discovery of the factors controlling the shift of fluid in the blood and tissues would be of great value. It is possible that if one could cause hemodilution to occur as it does after hemorrhage in a case of shock a cure might be effected. The observations which suggested that adrenal cortical extracts might be of value in shock were noted. It appears, however, that the normal animal may not respond in the same way as the adrenalectomized animal. The therapeutic use of

dried serum in shock was discussed. Hemoconcentration is apparently reduced, but in evaluating such treatment the time after and degree of shock should be considered, since hemoconcentration may be followed by hemodilution during recovery without any form of treatment. Experimentally, relatively enormous amounts of intravenous fluid may leave the blood stream. There is no reason why transfused isotonic serum should not escape to the tissues when the normal plasma of the blood stream has already done so, in cases in which shock is severe.

The Preservation of Blood. Abstract of Discussion by Dr. O. F. Denstedt: Numerous methods of preservation of blood by refrigeration have been described in the literature. All involve the use of so-called "preservative" or diluting fluids containing an anticoagulant such as sodium citrate and sometimes sodium chloride, glucose and other salts. A comparative study of the various methods recommended has been carried out in the Department of Biochemistry at McGill University and an improved method has been developed which makes possible the preservation of whole blood for several weeks.

From the study made it has been shown that, in addition to temperature and the composition of the diluting fluid, the proportion of blood and diluent has a marked influence on the stability of red cells during storage. Optimal stability, and hence preservation, is obtained when blood is diluted as follows and stored at 4°c.:

Blood—5 parts: isotonic (3.2 per cent) sodium citrate—1 part: isotonic (5.4 per cent) glucose—1.5 parts.

In this mixture the blood is diluted with half a volume of diluent (1:½). It is important that the diluting solution be isotonic with normal plasma. The addition of sodium chloride has always been found to impair preservation and the use of citrate alone is inferior to the citrate-glucose mixture.

Because of the difference in stability of individual bloods there is no one diluent which gives optimal preservation with all bloods. The above mixture and dilution have been found most satisfactory for bloods in general. The majority of bloods are not affected greatly in stability if the proportion of blood to diluent is varied between 1:¼ and 1:1. Dilution with more than an equal volume of diluent, however, renders the cells less stable to isotonic saline and to fresh plasma even though they may remain intact during storage.

As yet no method has been found for preventing the slow formation and precipitation of fibrin in blood or plasma during storage.

This process occurs regardless of the nature of the anticoagulant used and is more pronounced when "decalcifying" agents such as citrate, and antithrombin substances such as heparin, are used together than with either alone. The rate of fibrin formation is retarded by dilution of the specimen. It is much less in the dilution recommended above than in the $1:1\frac{1}{10}$ blood-citrate mixture used in many hospital blood banks.

It has now been established that red cells (blood) stored up to eighteen days survive and apparently function as well as fresh blood after transfusion. Blood stored for longer periods, although efficacious, is destroyed more rapidly in the recipient. It is anticipated that improvement in methods of preservation will extend the useful storage period. Cell survival studies on blood preserved by the method outlined above, are in progress.

6. *The Amniotic Graft* (*Dr. B. Alexander*). Destruction of large areas of conjunctival mucous membrane by trauma or disease, invariably requires repair by replacement. The use of skin, while providing unlimited amounts, has the disadvantage of its pale, dead-white color, the frequent presence of hair and a constant troublesome desquamation, which gives rise to a persistent irritation and an objectionable odor.

The ideal material for replacing conjunctival mucous membrane is mucous membrane itself. The amnion, a thin transparent, silvery, tough mucous membrane of great vitality and of few vessels, seems to be an ideal medium for use in the plastic surgery of mucous membranes. Its single layer of cuboidal cells is transformed into a stratified squamous noncornified epithelium, which later becomes indistinguishable from the surrounding conjunctiva.

The case presented showed the results a year after the repair of the outer half of a traumatic, contracted right socket by an amnion graft. The fornices were reformed, the color and appearance indistinguishable from the rest of the conjunctiva and the ability to wear an artificial eye was achieved.

7. *A Method for Handling High Intestinal Fistulas* (*Dr. E. A. Macnaughton and Dr. C. H. Crosby*). The presentation of this subject before a group of traumatic surgeons may be explained by stating that fistulas *do* result from trauma to the intestine in certain cases, be that trauma operative or otherwise.

The apparatus which is used in this method of treatment provides us with an extra-abdominal mechanical anastomosis, between the bowel above the fistula and the part distal to it. The bowel contents

of the upper loop are removed mechanically and automatically transferred to the lower loop without any spilling. They are fed slowly into it so that they are readily absorbed.

Consequently, there is no further depletion of body fluids nor electrolytes and the loss of digestive juices which may total many liters daily is completely eliminated. There is no digestion of surrounding skin.

The patient takes fluids and nourishment by mouth freely, the only precaution being that the fluids be clear so that the apparatus is not blocked by solids. Milk cannot be given as it is coagulated in the stomach.

The apparatus can also be used to anastomose a fistula, deliberately formed, as the first stage of a two-staged resection and anastomosis. When the patient's condition is poor, as it may be in gangrene of the bowel or extensive war lacerations, he could be saved the shock of the more time-consuming one-stage operation by this suggested two-stage method.

The apparatus is activated by continuous suction and its construction is simple. A fenestrated rubber tube five or six inches in length and of a diameter which is easily accommodated by the lumen of the bowel is inserted into the proximal or afferent loop and held in by tapes tied about its outer end secured to adhesive strips on the sides of the abdomen. Into this "well" is inserted a soft rubber catheter which has had several additional small openings made in its terminal two to three inches. This catheter must not fit tightly into the "well." This part is similar to the tip of an abdominal suction.

This catheter is connected by rubber tubing to the top of the glass reservoir which is a tube approximately twenty inches in length and of one and one-fourth inches inside diameter. From the bottom another tube leads directly to another soft rubber catheter which is inserted for almost its full length into the distal or efferent loop of bowel.

From the top of the reservoir another tube leads to suction. With peristalsis of the bowel, fluids flow into the well and the suction causes small amounts of fluid to rise, alternately with air, in the afferent tube and to spill over into the reservoir. This continuous column of fluid in the reservoir and efferent tube is heavier than the air and water in the afferent tube, so its weight causes the fluids to flow slowly and continuously into the efferent loop of bowel. By connecting a douche can to the afferent tube through a Murphy drip, additional nourishment as glucose solution can be fed directly to the

bowel. The apparatus requires little attention once it is set in operation.

When the fistula is too small to take a tube to serve as a "well" it may either be dilated to accommodate one or the fenestrated catheter only may be inserted into the fistula.

If it is impossible to pass a catheter into the lower loop, a jejunostomy should be performed to receive the efferent catheter.

Certain fistulas will heal completely with this treatment. Others will require intra-abdominal anastomosis when the patient's condition has sufficiently improved.

Dr. Crosby then presented two cases in which this method of treatment had been employed and resulted in a successful outcome. These cases illustrated the rapid improvement in the patient's general condition which follows the institution of this method of treatment.

8. *March Fracture Complicating Hallux Atavicus* (*Dr. J. W. McKay*). Hallux atavicus (Morton) is a structural defect of the foot characterized by a short mobile, abducted first metatarsal segment. This defect is an atavism.

The hallux of the monkey and ape is abducted, mobile and short. The function of the ape foot is prehension as well as the support of the body weight. The persistence of this atavism in the human produces a structurally defective foot.

The defect is compensated for by muscular action and by thickening of the second metatarsal bone. If compensation fails, pain develops in the foot. The pain may be clinically identified as metatarsalgia, march fracture, Deutschlander's disease or Kohler's disease of the second metatarsal. These diseases have a communal symptomatology and hallux atavicus is the predisposing cause.

To demonstrate hallux atavicus, an anteroposterior x-ray film was made of the foot.

ROYAL VICTORIA HOSPITAL

9. *The Relation of Histamine to Shock* (*Dr. Fram Rose, M.D.*). The marked similarity between the effects of large doses of histamine and the symptoms of traumatic shock led to the theory that the absorption of histamine or some similar substance might be the cause of traumatic shock. The histamine theory of shock was rejected, however, by many workers because an increase of histamine in the blood could not be demonstrated in traumatic shock.

It has recently been shown, however, that in burn shock and in shock due to trauma or surgical intervention there is a marked decrease in the histamine content of the blood. This finding, contrary to the original conception that the histamine content of the blood must be increased during shock, may be explained on the basis of previous work in which it was shown that in certain allergic conditions, i.e., angioneurotic edema and dermatographia, there is a decrease of blood histamine correlated with the edema and wheal formation. A decrease during such conditions is considered to be of more significance than an increase of blood histamine. This view is supported by the observation that following the injection of histamine there is a decrease in the blood histamine as symptoms are produced.

It may be that the low histamine in such conditions reflects a tendency to a loss of plasma from the blood stream such as occurs in shock. The decreased content of the blood histamine in such conditions, it is suggested, reflects a tendency to a loss of plasma from the blood stream into extravascular tissues.

10. *The Treatment of Nail Punctures (Dr. H. S. Dolan).* Forming a large percentage of accidents in construction where wood forms and trestle work are used are nail puncture wounds of the feet. Nail punctures may be very minor or they may be very serious, or what was a very minor injury at first may become very serious, owing to blockage of the entrance of the wound by the inverted skin flap and the sealing-in of micro-organisms with resulting local abscess formation or cellulitis. At the Beauharnois power development, where the statistics for this report were collected, prevention of this type of injury was carried out at all times. All lumber containing nails was piled. The men were instructed to wear heavy-soled shoes, but the very nature of the soil through which the canal was built necessitated the frequent wearing of long rubber boots, with the result that nail punctures were quite common.

On a construction work in a twenty-month period the daily average of men employed was 2,106. The total man hours were 19,430,992. The work was carried out under all sorts of weather conditions, winter and summer. During this period there were 3,401 nail punctures, a very large percentage of which were in the feet. They comprised 40.85 per cent of the total accidents, minor and major, which took place during the construction. It is interesting to note here that minor accidents, such as sprains, puncture and

lacerated wounds, and foreign bodies in the eye, comprised 93.6 per cent of the total accidents. There were in all 8,306 accidents.

But it is principally the nail punctures of the feet that are of interest to us in this report. In the total of 3,401 punctured wounds there were nine cases in which there was a loss of time, a total of thirteen and one-half days, that is, 0.21 per cent of the total lost this time. In these nine cases one man lost three days and he did not report the accident to his foreman until four days after the accident and then only because the foot was painful. On examination there was infection sealed in the track of the puncture and hot fomentations cleared this up in three days. The other patients lost, on the average, one day each and this because the area was painful. None of the patients were eligible for compensation for the loss of time, nor was there any resulting disability.

The procedure laid down to be carried out in all cases of this type was as follows: As soon as the workman suffered a nail puncture of his foot or hand he reported immediately to his foreman. Here the workman's responsibility ended and it became the duty of the foreman to send the man to the nearest divisional doctor immediately. No first aid was given on the job except to cover the wound with a sterile dressing and bandage.

On reporting to the doctor, the wound was examined, the skin cleansed with iodine, 2.5 per cent and the skin area for 1 to 2 mm. around the puncture wound was cut away with a sharp scalpel, removing at the same time the flap of the skin which is always inverted into the nail track. This gives sufficiently free access to and from the nail track. The same result may be obtained by making a crucial incision at the entrance wound and turning out the flaps and cutting away the edges. The wound was then examined for any foreign material, such as a piece of clothing, which may be carried in, especially by a rusty nail. The nail track was then swabbed out along its whole length with 5 per cent iodine by means of absorbent cotton on an applicator. A dry dressing or gauze soaked in alcohol was applied externally and the man reported for work. He reported to the doctor the following day, when the superficial wound was cleansed and a dry dressing applied. Few cases required such supervision for more than three or four days.

The objects of cutting away the skin around the puncture wound, thus forming an inverted funnel of the wound, are to allow drainage, to remove the flap of skin which is always inverted, to allow for

proper exploration of the wound for foreign bodies and lastly to permit sterilization of the track.

While this treatment may seem, at first sight, to be drastic, yet if one receives these patients a short time after the accident there is a certain anesthesia of the part which reduces the discomfort of the treatment and the results obtained in this large series justify, I think, the means adopted.

11. *Injuries about the Shoulder Joint (Dr. H. F. Moseley).* A colored moving picture occupying thirty-five minutes was shown, illustrating interesting lesions about the shoulder. This film included the diagnosis, operation and end result of a case of complete rupture of the supraspinatus tendon, also of a large calcified deposit in the same situation. Cases illustrating the mechanisms of the various parts of the shoulder girdle were shown, such as, a case of complete fixation of the scapula, a case of removal of the sternal half of the clavicle, two cases of adherent subacromial bursitis, and a case of ablation of the greater part of the trapezius and rhomboid muscles for actinomycosis.

12. *The Rôle of the Adrenal Cortex in Resistance (Dr. Paul G. Weil, M.D.).* The adrenalectomized animal is much less resistant to histamine and other toxic agents than the normal animal. One of the features of the response of normal animals to a nonlethal damaging stimulus is a hypertrophy of the adrenal cortex. The reduction in mortality in normal animals treated with adrenal cortical extract before their exposure to a lethal shocking stimulus such as severe intestinal manipulation is greater than in nontreated controls.

Using a method for the determination of cortin in human urine in a study of patients with infection and other forms of damage such as after burns and following surgical operation it has been found that cortin is excreted in the urine of such patients; cortin is not normally present in the urine. The appearance of cortin in the urine of conditions of damage is considered to be a manifestation of an increased secretory response of the adrenal cortex to damage.

The rôle of the secretion of the adrenal medulla in the defense mechanism of the organism was pointed out by Cannon. The results of investigations mentioned herein tend to suggest that the secretion of the adrenal cortex also forms part of the defense mechanism of the organism.

Editorial

THE PRINCIPLE OF NATURAL SELECTION APPLIED TO THE GENESIS OF CANCER

ANY theory of cancer must harmonize the facts that cancer occurs in a higher incidence in civilized man than in native man, and in native man than in wild and domestic animals; that cancer does not occur in cells of the highest metabolism, such as the cells of the heart, the cells of the voluntary muscles and the cells of the brain; that cancer is rarely if ever spontaneously arrested; that cancer does not occur in the fetus, and occurs rarely in infancy and childhood; that cancer occurs commonly in middle life and increasingly with advancing age; that cancer does not occur in normal uninjured cells, but occurs after prolonged, repeated injury and repair due to mechanical, chemical, bacterial, electrical or radiation factors.

A general theory of cancer must harmonize the facts that cancer cells perform little or no physiological function; that cancer cells utilize all their energy solely for growth; that cancer tissue exhibits a higher electric capacity, electric conductivity and electric potential than the normal tissue in which the cancer appears;[1,2,3,4,5] that cancer tissue bears a different sign of charge from that of the adjacent normal tissue;[6] and that the nucleus of the cancer cell is relatively

larger than the nucleus of the normal cell from which the cancer cell was derived.

A general theory of cancer must harmonize the fact that the growth per se of cancer is painless, in contrast with the defensive pain of infections.

It must also harmonize the fact that evolution did not favor the growth of cancer. Evolution favored the growth of the fetus by increasing the growth-stimulating secretions of thyroxin and pituitrin in the mother, by increasing the heart beat, the circulation of the blood, the metabolic rate and the appetite. In fact, the entire organism of the mother is stepped up to contribute to the growth of the fetus. Evolution contributed no such aid to the growth of cancer. Cancer has been blacklisted by evolution; the rest of the body does not collaborate in facilitating the speed of its growth.

A general theory of cancer must indicate a mechanism by which, through struggle and survival of the injured cells, a type of cell may be evolved which possesses the power of growth and little or no power of function; the theory must show that these cells within the area of injury and repair, through struggle and survival among themselves, may become the most power-

ful cells in the use of energy for growth alone.

A general theory of cancer must harmonize the fact that in the successful treatment of cancer by x-rays or radium, the electric conductivity, capacity and potential gradient of the malignant tissue decline to the level of the tissue in which the cancer grows, and coincidentally the cancer as a tumor disappears, and the great vascularity characteristic of cancer disappears.

The incidence of cancer is highly significant. In nature, cancer occurs rarely in wild and domestic animals, with possible exceptions in the dog and the horse, and in mice. Through breeding, man has modified the plant world and the world of domestic animals. In certain strains of laboratory mice, for instance, cancer appears in a high percentage of the animals. This fact does not conflict with the statement concerning the rarity of cancer in the animal world. On the other hand, it emphasizes the principle that cancer is produced by universal biological forces. Obviously, these cancerous animals represent modifications of the natural state by breeding.

Cancer is relatively rare among primitive races. Although, as stated by Hoffman, there are practical difficulties in determining the causes of death among noncivilized races, yet it is the opinion of qualified medical observers that among primitive peoples cancer is not met with to anything like the degree common to practically all civilized countries.

Cancer is rarely seen in the younger age groups of mankind. It seldom occurs in fetal life, in infancy, in childhood or in adolescence. With advancing age, cancer appears in man in a gradually increasing percentage until senility and death.

Cancer does not occur in tissues making up perhaps three-fourths of the human body. It is not found in the entire mass of voluntary muscle fibers, or in smooth muscle fibers. It is not found in the blood, in either red corpuscles or white corpuscles. Cancer does not appear in nerve cells; it is not seen, for instance, in cells of the cortex of the brain. But cancer does appear in epithelial cells, in connective tissue, in bone, in fact in all the other tissues of the body.

Furthermore, normal, uninjured cells do not spontaneously become cancer cells. The highest authorities, from the time of Billroth to the present day, are in agreement with this statement. This is not inconsistent with the fact that benign tumors, especially the adenomas, not infrequently become cancer, since the cells of the benign tumors are not normal cells.

Now, each normal cell is in electrical equilibrium with the adjacent cells.

We will consider that the cancer cell is a normal epithelial cell that has lost its electrostatic balance with its neighboring cells, hence exists as an independent biologic unit; that in the process it has lost nearly all of its power of function and has gained an increased power of growth; that the individual cells under continued mechanical, chemical, bacterial, electrical or radiation stimulation, types of stimulation exerted singly or in combination, are subjected to injury and repair; and that in the cellular melee of struggle and survival natural selection offers to the fittest cell the entire body of man for its endless growth.

In this genesis, the establishment of a single cancer cell would be analogous to the introduction of a deadly germ, a single virulent bacterium, into the body.

When a local area is subjected to mechanical, chemical, bacterial, electrical or radiation injury, electric currents are induced, and these persist until repair is established. The "current of injury" would seem to be an important factor in the repair of injured cells. We are now in possession of a new fact which assigns to the "current of injury" a definite source and a more probable relation to growth and repair.

The brain and other nerve tissues bear a positive sign of charge, and all other

tissues of the body bear a negative sign of charge. The production of the positive ions in the brain is due to oxidation. What then is the source of the negative ions which constitute the "current of injury"?

I postulate that the heart and the red blood cells constitute the source of the negative ions. A basic fact supporting this hypothesis is the thickness of the film surrounding the red blood cell. Fricke[7] in our laboratories determined that the thickness of this film is on the order of 1/2,500,000 cm., approximately that of a molecule of oil. This lipoid film because of its extreme thinness is ideally adapted for holding static electricity. The question arises, what is the source of this static electricity?

There is a principle that a particle moving through air or through water accumulates static electricity in relation to the speed of movement and the amount of friction. Examples of this principle are seen in the formation of dust in which wind is the source of friction. Another example of this principle was observed by Lenard in Switzerland in 1892, when he detected that the particles of water passing through the air in a waterfall took on negative charge.

I postulate that this principle of the accumulation of charge of static electricity by particles moving through air or water is equally applicable to the red blood cells. The left ventricle, in its contraction, through friction and speed of movement would cause a charge-up of static electricity on the films surrounding the red blood cells. As the blood moves from the high velocity in the left ventricle through the branches of the arterial tree to the capillaries, there would be a distribution of this static negative electricity held on the films surrounding the red blood cells. As the red blood cells slowly squeeze their way through the capillaries they would distribute the greater part of their negative charge to the adjacent tissues. Thus with each heart beat there would be distributed through the red blood cells, or

accumulators, a quantum of electric charge to every microscopic unit of living tissue.

In testing this hypothesis experiments were performed upon 377 animals in our laboratories.[8,9] It was found that during life there existed an electrical potential gradient between the brain as the positive pole and the blood as the negative pole. Each heart beat caused an increase in the difference in potential. Each increase in the force and frequency of the heart beat correspondingly increased the difference in potential. When the flow of venous blood was completely interrupted at the point of entering the right auricle, the difference in potential decreased abruptly. On arrest of the heart, the potential gradient dropped almost instantly to the death level. Throughout living tissue, there is the universal presence of potential gradients.

Not only the life, but the growth and repair of tissue is dependent upon the presence of potential gradients. In other words, the universal source of the energy of growth and repair is the negative or static charge on the red blood cells. The greater the requirement for growth and repair, therefore, the greater the need of vascularization.

This agrees with the clinical fact that in a local area of repeated, long-continued injury and repair, there is a concomitant increase in vascularization. This increased capillary circulation brings a corresponding increase in the negative potential brought to the injured area by the increased number of red blood cells. As a consequence, there is established in the area of injury an increased electrical conductivity, electrical capacity and electrical potential, which in turn increase the power of tissue repair. In fact, the increased electrical conductivity, electrical capacity and electrical potential are the principal source of the power of growth and repair. In short, the "current of injury" tends to reconstruct the injured cells. But if the structure of a given cell is injured to the extent that the mechanism for function is lost, the cell reconstructed by the "current

of injury" would possess only the mechanism for growth. Thus a cancer cell would be evolved.

This hypothesis is consistent with the high incidence of cancer in civilized man as compared with native man. It is obvious that in warm-blooded animals there is a greater increase of vascularization in the course of injury and repair than in cold-blooded animals. Among warm-blooded animals there is a greater vascularization and power of repair in the northern climates than in the tropics. The vigor of the man in the north is an adaptation to cold. The organs of adaptation to cold are the brain, the thyroid gland, the heart and the blood volume. Thus the larger brain, larger thyroid gland, larger heart and blood volume, the neuro-endocrine formula of civilized man, offer a greater vascularization, hence a greater "current of injury," hence a greater power of growth and repair in man in the temperate zones than in man in the tropics.

A consequence of this greater power of repair in man in the temperate zone is that injured epithelial cells will receive more effective electrical stimulation, hence will be more effectively restored, in the vigorous civilized man of the north than in the native of the tropics.

Thus the incidence of cancer in civilized man is higher than in tropical man. Civilized man lives longer than native man. Civilized man excels native man in intelligence, power and personality. Not only cancer, but also exophthalmic goiter, peptic ulcer, diabetes, and nervous and mental diseases, all reflecting overdevelopment of the energy-controlling organs, are higher in civilized man than in native man.

In the melee of injury, then, in the presence of electrical forces influencing repair and growth, vast numbers of epithelial cells are partially or completely destroyed and many are repaired. These individual cells undergo struggle and survival, just as animals undergo struggle and survival in the vicissitudes of life and the fittest cells survive. At some point it

may happen that one cell becomes possessed of a larger nucleus than is possessed by a normal cell. This cell that possesses a larger nucleus may have suffered such great damage to the cytoplasm that it has lost that mechanism in the cytoplasm by which it performed its function. The new cell would have, accordingly, a high growth energy, for none of the energy of the cell is expended for function, and all of it is expended for growth. This cancer cell is the epithelial cell that has gone through the struggle in the area of injury and repair and has emerged as the fittest cell for growth only. In other words, we can apply the principle of natural selection through struggle and survival among individual cells in the process of injury and repair, in an interpretation of the origin of cancer.

It has been stated that among the living normal cells of organs and tissues there is an electrostatic equilibrium, and that the "current of injury"[10] sets up a difference in potential between the injured cells and the normal cells. Moreover, when an adenoma appears, as for instance in a thyroid gland, there is also a difference in potential between the adenoma and the adjacent normal tissue, and an electric strain is established. In many cases benign tumors are thus situated in the midst of normal tissue under unequal electric equilibrium and with electric strain between the benign tumor and the normal tissue. As a result of this electric strain, cancer may be produced, not in the normal tissue but in the benign tumor. Similarly, if two metals of different atomic weight are used in filling a tooth, there will be set up electric currents between them which will ultimately destroy the tooth. Theoretically, this electric strain would cause cancer at the base of the tooth.

Whereas no normal cell has a biological career of its own and no normal cell can metastasize, the cancer cell in its freedom metastasizes through the lymphatic channels and sometimes through the blood stream. And since that cancer cell as an

individual is adapted to the chemical affinities of the whole organism, it can grow anywhere.

It has become detached from the electrostatic and physical state of its fixed position in relation to adjacent cells, and by a process of devolution has returned to the level of its unicellular ancestor, which existed eons ago. This cell, having lost the mechanism in its cytoplasm by which it performed its function, and possessing now the power of growth only, exists as a biological unit. This independent cell, like its ancient progenitor, has the power of assimilating food, of respiration, of growth, of metabolism and cell division.

Only rarely does it retain to some extent the function for which it was evolved. The mechanism by which the function of a cell is performed is more recent in phylogeny than the primordial mechanism of the unicellular ancestor that was evolved for growth and cell division only. It is clear that the formula of growth and cell division is more basic than the specialization of the cytoplasm for function.

There is definite evidence that the mechanism which effects the maintenance and growth of all cells exhibits a lower stage of evolution than the mechanism of function. This evidence is seen in the fact that the mechanism of growth is more resistant than the mechanism of function.

For instance, in the repeated injury and repair of skin of the hands and arms, the cells of the skin exhibit a loss of function, as seen in loss of sweat glands and in loss of softness. Many cells are destroyed and replaced by scar tissue. In the course of months or years, the growth mechanism steadily increases in the cells of the skin. With repeated generation of unbalance between the growth mechanism and the functional mechanism, the cells finally lose completely the mechanism of function and keep the ancient unicellular mechanism of growth only.

Moreover, x-ray or radium application may be so adjusted as to suspend or destroy the mechanism of cellular function and not destroy the mechanism of cellular growth. This is seen in radiation of the salivary glands.

The beginning of specialized function in the unicellular organism is exemplified in the diplodinium. In the diplodinium the nucleus is evolved as a diminutive brain, and from this nuclear brain, nerve fibers extend to the base of the flagellae. The flagellae are the antecedents of the arms and legs and wings of the higher animals. The specialized nucleus and the nerve communications to the flagellae are the analogue of the brain and the nervous system of the higher animals and man. In other words, in man the brain is the exalted nucleus of the diplodinium. The spinal cord and nerve fibers in man are the exalted simple nerve communications between the nucleus and the flagellae in the diplodinium.

From the diplodinium throughout the multicellular animals, increasingly higher degrees of specialization were evolved, culminating in man. In man, indeed, many cells have become so highly specialized, and exist under such special conditions, that they have lost their ancestral basic mechanism of growth and cell division only. A large part of the body of man is constituted of cells so specialized that under the most extreme degree of chronic mechanical, chemical, bacterial, radiation or electrical injury, they cannot lose their specialized function and exist as cells with the power of growth only; they cannot be reduced to cancer cells. Among the cells that cannot be reduced to cancer cells are the twenty-five trillions of red blood cells. Among the cells that cannot be reduced to cancer cells are those that comprise the entire voluntary and involuntary muscular system. Among the cells that cannot be reduced to cancer cells are the nerve cells, including the trillions of cortical brain cells of man.

The red blood cells possess no nucleus. Their protoplasm is maintained and their function is performed by the universal negative potential in the entire vascular

system, produced by the heart's contractions. Here electric strain exemplifies in the most perfect way the power of maintaining protoplasm and of performing function.

The voluntary muscles comprise by far the greater part of the weight of the body. They execute the greater part of the metabolism of the body; they perform the mechanical work of the body. They do the walking, running, fighting.

The muscle cell, or more correctly the muscle fiber, is indeed not a cell but an example of extreme specialization as the result of a nucleus-plasma evolution. The voluntary muscle fiber represents the protoplasmic evolution of the cytoplasm, just as the brain cell represents the evolution of the nucleus. The muscle fiber is the cytoplasmic partner of the brain cell, communicating with it by a nerve fiber. The brain cell and the muscle cell together constitute the most important physiological unit of the higher animals and man.

The close relation of the brain cell and the muscle fiber is simply demonstrated by severing the nerve communication between them. This is equivalent to taking apart the nucleus and the cytoplasm of the unicellular ancestor. Severing the nerve communication between a brain cell and a muscle fiber produces striking immediate and remote effects. The immediate effect is complete paralysis of the muscle fiber. The remote effect is the complete loss of the muscle fiber as a living entity. The function of the nucleus of the muscle fiber is so insignificant that it cannot be maintained. Therefore, chronic mechanical, chemical, bacterial, radiation or electrical injury of any degree or of any length of time cannot transform a single unit of the most massive, most powerful mechanism of the body into a cancer cell.

The same reasoning holds for the heart muscle and the smooth muscle fibers of the body. They cannot be reduced to the status of a cancer cell. Evolution has so specialized the voluntary muscle fibers, the heart muscle fibers, the involuntary muscle fibers, that they have lost their identity as cells with a nucleus-plasma relationship, and are incapable of sustaining themselves independently, much less of becoming cancer cells.

The positive electric stimulation of all these specialized muscle fibers is derived from the brain cells; the negative electric stimulation is derived from the friction in the movement of the red blood cells in the adjacent capillaries.

We have applied the principle of natural selection, struggle and survival to the life history of the cells of the body that may become cancer. Furthermore, we have put to experimental test the idea that cells may be reduced completely to a nonliving state, then reassembled as cells having all the characteristics of the ancient unicellular organisms.[11,12,13] Such reassembled cells would have lost their power of function and would retain only their power of growth.

The cancer cell, like every living cell, is made up of proteins, lipoids, and electrolytes. The brains of freshly killed normal animals were dried and ground up, the lipoid and protein fractions were extracted, and the ash, or electrolyte fraction, was obtained. These lipoid and protein fractions and a solution of the electrolytes were mixed together. Beautiful cells formed instantly; they grew, divided and exhibited respiration. They were killed by anesthetics, poisons and radiation. The respiration of these cells was increased by thyroid extract and iron. These cells emitted ultraviolet radiation during their formation. The only food that these autosynthetic cells could utilize was protein derived from the species which supplied the brain from which they were formed.

These cells continued to be active in cultures for eight months. The successive generations obeyed the laws of inheritance, the daughter cells resembling the mother cells.

In other words, in this experiment we took cells that had a highly specialized power of function but no power of growth,

and made of them cells that had no power of function but had the power of continuous growth.

It has been stated that cancer cannot develop in the organs of the highest metabolic activity, such as the brain, the heart and the voluntary muscles. In addition, cancer cannot grow at the expense of the tissue of highest potential.

Now it has been shown that the red blood cells carry negative charge, therefore electrically stimulate every microscopic tissue of the body, the stimulation being related to the degree of vascularity of the tissue. If this is true, then it would follow that the highest degree of energy in animals and in man would be found in the growth of the fetus. The growing fetus, through the highly vascularized placenta and through the highly vascularized new tissues in the process of formation, presents an example of the highest growth energy, therefore, the highest electrical stimulation from the blood stream. For a certain period after fertilization all the energy, radiant and electrical, is utilized for growth only. From an energy point of view, then, the fertilized ovum and the cancer cell proceed along parallel lines. But the growth energy of the fetus exceeds the growth energy of cancer. Therefore, cancer could not develop in the fetus.

The high vascularity incident to cancer tissue is analogous to the high vascularity of the placenta and fetus. In the case of the cancer as in the case of the fetus, the growth energy is supplied by the blood stream. The factor in the blood stream that produces growth energy in both the cancer and the fetus is the electrical stimulation supplied by the charged up red blood cells. Electrical stimulation is identical in nature, whether it causes the growth of the fetus or the growth of cancer.

Both the fertilized cell and the cancer cell have the power of growth and the power of cell division. In other words, each possesses a highly energized nucleus, hence a highly increased cellular potential. But the fertilized ovum and the "fertilized"

epithelial cell are different in this respect: In the fertilized ovum there is the mechanism which eventually produces the organs and tissues of the fetus, the infant and the man. In the "fertilized" epithelial cell, there is neither in the nucleus nor in the cytoplasm any pattern of an organ or a man, but only the power of cell division and growth, as in the unicellular progenitor of millions of years ago, and as in the autosynthetic cell produced in the laboratory of the present day. The cancer cell possesses the formula of growth only; moreover, it possesses the pattern of rapid growth only. Whereas when the cells of the fetus, the child and the man are completely differentiated, the electrical potential supplied by the red blood cells is utilized for function and not for growth.

By means of the physical constants, electrical conductivity, electrical capacity, and electrical potential, we have studied cancer in man and animals. Our first biophysical investigation of cancer consisted of a series of comparative measurements of the electrical conductivity of normal and of pathological tissues. In this study we measured 219 sections from 159 clinical cases. These included malignant and benign tumors of the breast and of the uterus, ulcer and carcinoma of the stomach, carcinoma of the rectum, malignant and benign tumors of the mouth, jaws and neck, x-ray burns and various types of goiter, including hyperplasia, fetal adenoma, multiple adenoma, toxic adenoma, exophthalmic goiter, simple colloid goiter and thyroiditis. Whenever possible, adjacent normal tissue was measured for comparison. The pathological diagnosis and differentiation of different types of tissue in single specimens was made by a pathologist.

In all instances in which comparative measurements were made, the conductivity of the malignant growth was higher than that of a normal portion of the same organ.

The outer, growing parts of cancers showed a high conductivity in contrast with the conductivity of the central, nongrowing parts.

Among the goiters studied the highest conductivities were found in the degenerating adenomas and the malignant thyroids; the conductivities of the hyperplastic thyroids were lower; and the conductivities of the colloid goiters were the lowest of all the pathological tissues studied.

This line of inquiry was further extended, when the theoretical requirement that cancer tissue must have a high capacity for the storage of electric charges was tested. Eighty specimens from fifty-three cases were investigated, including fifteen carcinomas of various types, three sarcomas, three benign tumors, and sixteen goiters of various types. All of the carcinomas had a relatively high capacity in the actively growing portions of the growth. The degenerated portions of the growth had a lower capacity, and radiated tissues a much lower capacity. In every case studied the cancer itself had a higher capacity than the tissue in which the cancer had developed. This difference was particularly marked in the case of carcinomas of the breast, in which the capacity of the cancer was often over ten times as high as that of the adjacent glandular, connective or fatty tissue. Adenomas and hyperplastic thyroids had, as a rule, a higher capacity than the normal thyroid tissue. In general, glandular tissue seemed to show a somewhat higher capacity than normal tissue. Connective tissue had usually a very low value, and the capacity of fatty tissue was also low.

According to our conception, cancer cannot grow unless a difference in potential is maintained between the cancer mass and the surrounding tissue. Of special significance, therefore, was the finding that the electric potential of a cancer has an opposite sign of charge to that of the tissue in which it is growing, the degree of difference apparently varying with the malignancy of the growth.

In a series of experiments on rats, direct observations were made of the sign of charge of cancer. It was found that cancer exhibited a different sign of charge than that of the adjacent normal tissues. A series of experiments was performed in which a measured current of electricity and a solution of sodium chloride were so manipulated that by ionization the potential of the cancer became the same as that of the normal tissue surrounding it. The cancer diminished in size during the course of treatments with the electrodes placed in one position; by reversing the poles, we could cause the cancer to grow; and when the electrodes were again reversed, the cancer would again diminish. When the cancer potential was brought to and maintained at the level of the potential of the normal tissue, the cancer disappeared.

Such experiments were successful in about 30 per cent of the cases. These experiments are not conclusive, for they dealt with transplanted cancers in rats, which are rather easily cured and are not easily induced; but the results of the experiments cited are in harmony with our theory and support it.

The fact that cancer exhibits a different sign of charge from that of adjacent normal tissue agrees with our conception that cancer cannot grow unless a difference in potential is maintained between the cancer mass and the surrounding tissue. This conception is in accord with certain clinical facts. When muscles are repeatedly stimulated electrically, they increase in size. If the motor nerve supplying a muscle is divided, the continuous bio-electric current is shut off and the muscle atrophies. Exercise of all kinds is the equivalent of electrical stimulation. Electrical stimulation increases electrical potential. Electrical stimulation and electrical potential are related to the growth of protoplasm.

Moreover, when two tissue cells are in biological contact, the cell having the higher potential controls the cell having the lower potential. Therefore, a cancer cell can invade—can overcome—no cell that has a higher metabolism than its own.

Our findings, therefore, support the conception that a fertilized ovum would act as a cancer if the ovum were in contact with ordinary cancer, that the ovum would,

theoretically, overcome the cancer just as cancer cells overcome the neighboring cells of lower activity.

Our findings support the clinical observation that in adults, cancer does not develop among cells of a high electric potential, that cancer does not originate in the cellular units of the gray matter of the brain, the heart muscles, the voluntary muscles or the involuntary muscles; for the metabolism and the potential of the cells of these tissues are higher than those of cancer cells.

True, cancers are seen in the organs in which these tissues are found, but the cancer cells originate not in the highly metabolic cells of these organs but rather in the connective tissue cells and other cells of lower metabolism. The epithelial cells that cover or line the surface of the body, of the hollow organs and of their ducts, do not have a high metabolism, hence these cells are the frequent hosts of cancer.

It would seem that the principle of natural selection, as applied to the struggle and survival of individual cells in the zone of prolonged, repeated mechanical, chemical, infectious, electrical or radiation injury, explains many of the facts associated with cancer. It agrees with the conception that the "current of injury" and the power of repair by the electric forces in the tissues are established by the heart and the red blood cells and the vascular tree in their rôle of an electrostatic generating system. It explains the establishment of a characteristic difference between cancer and normal tissue, in electrical capacity, electrical conductivity and electrical potential, in the precancer as well as in the cancer stage. It explains the high incidence of cancer in civilized man, as compared with native man and wild and domestic animals.

Finally, this theory is in harmony with the fundamental conception that cancer obeys biologic laws: By the process of devolution, the cancer cell, like the autosynthetic cell of the laboratory, has lost the power of function and retains only the power of growth. It has reverted to the primordial pattern of the ancient unicellular ancestor of animals and man.

The production of autosynthetic cells in the laboratory has been described. This suggests a clinical analogy. Not only might physical injury cause a cell to be built up to the level of a cancer cell as a result of an induced potential, but if numbers of cells are reduced to their protein and lipoid fractions, then by an autosynthesis, new cells may be formed out of the material. Thus, as with fertilization in the production of the whole animal, cells endowed with the vigor of growth only may be produced. This autosynthesis also would be aided by the stray electric or injury currents.

Thus the occasional sarcoma of the thigh which follows a single crushing injury of all the soft parts down to the bone, leaving the skin intact, might be explained as due to autosynthesis. It is significant that this sarcoma sequence occurs only after a heavy blow or extensive crushing. This is comparable to the incidence of sarcoma in bone following a single blow, or in tissues which have not been lacerated and have incurred no infection; there has been no interference with Nature's biologic cover, so that there is no interference with the fullest development of bio-electric currents.

GEORGE CRILE, M.D.

REFERENCES

1. CRILE, GEORGE. Electric conductivity observations on malignant and benign tumors, with a further note on operations for cancer of the large intestine. *Tr. South. S.A.*, 33: 149, 1921.
2. CRILE, GEORGE, HOSMER, H. R. and ROWLAND, A. F. The electrical conductivity of animal tissues under normal and pathological conditions. *Am. J. Physiol.*, 60: 59, 1922.
3. CRILE, GEORGE. An electro-chemical theory of normal and certain pathological processes. *Proc. Am. Philosoph. Soc.*, 60: 346, 1921, also in *Bull. M. & Chir. Fac. Maryland*, 14: 21, 1921.
4. FRICKE, HUGO and MORSE, STERNE. Measurement of electric capacity of tissues of the breast. *J. Cancer Research*, 10: 340, 1926.
5. CRILE, GEORGE. A Bipolar Theory of Living Processes. Chap. 8. New York, 1926. The Macmillan Company.
6. A theoretical conception of the mechanism by which a normal cell is changed to a cancer cell. *Acta, Union internat. contre cancer*, 2: 362, 1937.

7. FRICKE, HUGO. Electric capacity of suspensions of red corpuscles of a dog. *Physical Rev.*, 26: 682, 1925.

8. CRILE, GEORGE, GLASSER, OTTO and QUIRING, D. P. The heart and the red blood cells as generator and distributors of static electricity. *Ohio J. Sc.*, 41: 347, 1941.

9. CRILE, GEORGE. Intelligence, Power and Personality. Chap. 2. New York, 1941. Whittlesey House.

10. CRILE, GEORGE, TELKES, MARIA and ROWLAND, A. F. An investigation of the physical nature of cancer cells. *Am. J. Cancer*, 15: 2659, 1931.

11. CRILE, GEORGE. Research into the formation of autosynthetic cells, with special reference to fertilization, production and growth of cancer cells and the cause of fatty degeneration. (Wm. Potter Memorial Lecture) *Am. J. Surg.*, 12: 213, 1931.

12. CRILE, GEORGE, TELKES, MARIA and ROWLAND, A. F. Autosynthetic cells. *Protoplasma*, 15: 337, 1932.

13. CRILE, GEORGE, TELKES, MARIA and ROWLAND, A. F. The nature of living cells, with special reference to the nature of fatty degeneration. *Arch. Surg.*, 23: 703, 1931; also in *Cleveland Clinic Quart.*, 1: 3, 1932.

CONSERVATION OF SCHOLARLY JOURNALS

THE American Library Association created this last year the Committee on Aid to Libraries in War Areas, headed by John R. Russell, the Librarian of the University of Rochester. The Committee is faced with numerous serious problems and hopes that American scholars and scientists will be of considerable aid in the solution of one of these problems.

One of the most difficult tasks in library reconstruction after the first World War was that of completing foreign institutional sets of American scholarly, scientific and technical periodicals. The attempt to avoid a duplication of that situation is now the concern of the Committee.

Many sets of journals will be broken by the financial inability of the institutions to renew subscriptions. As far as possible they will be completed from a stock of periodicals being purchased by the Committee. Many more will have been broken through mail difficulties and loss of shipments, while still other sets will have disappeared in the destruction of libraries. The size of the eventual demand is impossible to estimate, but requests received by the Committee already give evidence that it will be enormous.

With an imminent paper shortage attempts are being made to collect old periodicals for pulp. Fearing this possible reduction in the already limited supply of scholarly and scientific journals, the Committee hopes to enlist the co-operation of subscribers to this journal in preventing the sacrifice of this type of material to the pulp demand. It is scarcely necessary to mention the appreciation of foreign institutions and scholars for this activity.

Questions concerning the project or concerning the value of particular periodicals to the project should be directed to Wayne M. Hartwell, Executive Assistant to the Committee on Aid to Libraries in War Areas, Rush Rhees Library, University of Rochester, New York.

Original Articles

REDUCED TEMPERATURES IN SURGERY*

III. EXPERIMENTS ON PELVIC AND ABDOMINAL REFRIGERATION WITH ESPECIAL REFERENCE TO TRAUMATIC AND MILITARY SURGERY

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THE advantages hoped for from refrigeration in amputations for gangrene are ease and quickness, absence of pain both during and after operation, inhibition of infection, conservation of poorly nourished tissues, control of edema, promotion of drainage when necessary, probable reduction of thrombotic and embolic dangers, and pre-eminently the avoidance of shock.[1] Transfer of these results to war conditions offers hope of transportation of limb casualties without hemorrhage, pain or shock, without advance of infection or tissue devitalization, with minimum damage and maximum time limits of tourniquet application and with freedom to operate without an anesthetic or to delay for several hours according to the exigencies of a crowded surgical service. As regards practicability, refrigeration is usually available on naval vessels, and for modern mechanized armies a 200 pound apparatus is obtainable, which can be operated by the motor of a truck or ambulance and can refrigerate four to six limbs simultaneously. Ice is frequently available in less fortunate countries, from Finland to China, where the lack of anesthetics has entailed much suffering. Many experiments are needed to test the validity of these hopes. Existing conditions seem particularly to demand investigation as to how far refrigeration can be serviceable in traumatic and military surgery.

With reference to the urgent problem of military surgery of limbs, the observations of Brooks and Duncan (cf. discussion of paper of Bancroft and Ruggiero, meeting of Southern Surgical Association, December, 1941) may be correlated with other existing information as follows:

1. The first work of Brooks and Duncan[8] was a confirmation, in rats' tails, of my previously published observations on legs of various species. There is full agreement concerning the absence of harm to normal limb or tail tissues from temperatures slightly above freezing, unless perhaps when continued for several days. Pressure being recognized as harmful, these authors avoided the localized injury of a tourniquet by extending the pressure over the entire tail. Therefore, even the slight atrophy following several days without circulation was a result of cold plus pressure, and no injury from cold alone has yet been clearly demonstrated.

2. Recently, Brooks and Duncan[9] used a skin patch test to show that when a staphylococcus culture or an aseptic irritant (turpen-

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tine) is injected intradermally, the local effects are repressed by cold and augmented by heat; but when the cold is withdrawn after two days, the extent of injury is greater than in control patches left at normal temperature. As such experiments do not disprove the benefits of hot applications for infections under proper conditions, so also they must be interpreted in regard to cold according to existing broader information, as follows:

(a) Gangrene being the object of my study, rattlesnake venom was used[10] for producing an aseptic wet gangrene with an extreme tendency to spread and become infected. Cold could inhibit this process but could not stop the spread of the poison.*

(b) Temporary chilling of the peritoneum[11] was found to lower its resistance to an injection of Staphylococcus albus culture.

(c) When a badly infected limb is subjected to the tourniquet and refrigeration for an extremely long time (e.g., twenty-four to forty-eight hours), the restoration of circulation may be followed by a rapidly fatal gangrene indicating a wide diffusion of bacterial toxin during the chilling.[1,12]

3. Although these possibilities of altered tissue permeability and of harm from wrong use of cold have been continually considered in both our experimental and clinical work, actual clinical experience comprises the following:

(a) The published reports of Temple Fay, McElvenny and others showing benefit and not harm from local cold applications for long periods without a tourniquet.

(b) Unpublished cases of embolism (Hurley) or arteriosclerosis and infection (McElvenny) in which the patients were treated with continuous ice packs for ten to thirty days, with favorable results. These cases furnish the only information yet available on anemic tissues subjected to very prolonged cold without pressure.

(c) Absence of microscopic damage in legs

* The spread of jungle fighting may introduce snake bite as a minor war casualty. This research emphasized the uselessness or actual harm of the temporary or intermittent tourniquets which most doctors are still disposed to use. Antivenine being seldom at hand in the emergency, it should be understood that bites on the limbs (which are more than 90 per cent of the total number) need never be fatal if a proper selection is made among the surgical treatments of (a) incision and suction, (b) wide excision, and (c) permanent tourniquet followed by amputation (best with refrigeration but feasible also without).

amputated after refrigeration, and benefit instead of injury clinically in the stumps (Crossman, Lisa).

(d) A poorly nourished edematous leg, bearing a very large, old, infected ulcer, on Dr. Crossman's service, to which I applied tourniquet and refrigeration for six hours, then released for observation of the effects. No tissue injury or extension of the ulcer or infection was perceptible clinically or in the pathological examination of the leg amputated four days later.

4. The skin patch experiments fail to cover the following practical applications of refrigeration:

(a) The Fay method of applying cold without tourniquet continuously until the infection or other morbid process comes to an end.

(b) The previously discussed[1] local and constitutional injury and shock from accident or operation, of such severe degree that they cannot be overcome by the unaided bodily powers as easily as a skin prick.

(c) The states of impaired circulation and vitality represented in arteriosclerotic limbs or traumatized areas, in which the lowering of metabolism by cold was designed to compensate for the reduced nutritive supply.

5. The temporary emergency uses of cold are among the most important, for example:

(a) To check pain, shock, infection, etc., during transportation or preparation for operation.

(b) To gain time for transfusion and other restorative measures.

(c) Theoretically, to provide opportunities which were very inadequately tested in experiments.[12] such as stopping toxic absorption while antitoxin is injected either systemically or locally.

Brooks and Duncan's observations are not out of harmony with these numerous facts and need not create apprehension concerning any proper use of refrigeration.

Starting with the above mentioned experience with leg operations, it seems clear that both arms or both legs can be amputated as high as a tourniquet can be placed. One of the greatest benefits to be expected is the reduction of shock to a minimum. If a tourniquet is needed not for amputation but for temporary stopping of hemorrhage, it is known from animal experiments that one or several limbs can

be safely deprived of circulation with the aid of refrigeration, and the efficiency of the chilling will determine the time limits and the prevention of tissue devitalization or infectious developments.

When the injury is too high to permit of a tourniquet, the bleeding vessels can be hastily clamped or tied and the wounded area refrigerated with ice or apparatus. This was the procedure by which Mc-Elvenny,[2] in a case of amputation of both legs by a railway train, controlled pain and infection for three days until the moribund patient could be restored sufficiently to undergo operation.

In proceeding beyond the limbs, there is the possibility of prolonged treatment by the method of Temple Fay,[3] who has demonstrated that local chilling can be used in practically any region, including the central nervous system, and can be continued for days, weeks or months. The possibilities of this method for infectious and other conditions are not yet fully ascertained or appreciated. The brief drastic refrigeration which includes the use of a tourniquet can be extended beyond the limbs only by studying two problems. One of these is a question of the total mass or proportion of bodily tissue which can thus be chilled into a state of suspended animation without fatal shock or other dangers. The other concerns the tolerance of different individual organs for cold and absence of circulation. This combination is impossible for the central nervous system, but appears to be harmless for peripheral nerves and ganglia. A series of unpublished experiments performed on dogs and cats with the co-operation of Dr. George L. Birnbaum indicated that the lungs are absolutely intolerant of ligation with chilling. On the other hand I found in a few trials that the thyroid readily endures both simple chilling and ligation with chilling for a number of hours, so that there is a theoretical hope that cold may become a useful aid in the stormy period of some operations for toxic goiter.

The principal part of the trunk to which refrigeration can possibly be applied is the abdomen. There is good reason for an advance assumption that the various abdominal organs will differ in their individual tolerance. Also it is necessary to consider closure of the abdominal aorta and the reduction of something like half the total body mass to a state of frigid inanition. This use of cold is not for anesthesia, as in the case of the limbs, because an abdominal tourniquet is distressing and is practicable chiefly in unconscious or previously anesthetized patients. The emergencies for which such heroic treatment may be contemplated are essentially three:

(a) *Hemorrhage.* The use of an abdominal tourniquet when all other measures are unavailing is not theoretical but has been familiar especially to obstetricians. Not only is bleeding instantly stopped in the lower part of the body, but also in the upper part there is a rise of blood pressure, a reduction of the demand upon the heart and vasomotor system, and an increased effectiveness of transfusions and restorative measures.

(b) *Shock.* Wounds or burns may be of such degree as to be fatal without treatment, yet the patient will die of the added shock entailed by operation. The tourniquet and refrigeration offer immediate blocking of both nerve impulses and chemical sources of shock, allowing an interval for both operation and recuperation.

(c) *Infection.* Examples are the rapid growth of gas-forming and other bacteria in mangled tissues, and the flooding of the peritoneum with the contents of ruptured intestines. Both the beginning infection and the toxic absorption can be checked if refrigeration is feasible.

The use of an abdominal tourniquet alone, without refrigeration, has been limited by three kinds of harm or danger:

(1) *Shock and Intoxication.* An abdominal tourniquet applied for one and one-half to two hours will cause fatal shock in a rat. The time limit for survival in dog and man is several times this period, though not determined exactly. These limits are greatly

shortened by pre-existing shock, and any relief gained during the brief period of tourniquet application will be more than counterbalanced by the increment of shock following release of the tourniquet. Furthermore, in the case of extensive wounds and infections, the accumulation of toxic products of devitalized tissues and bacterial activity contraindicates the method unless for the briefest period.

(2) *Paraplegia.* The degree and duration of paralysis are in proportion to the duration of tourniquet application, and may with long application be serious.

(3) *Organic Injury.* Care is necessary that no solid organ be caught in the grip of the tourniquet, because the injury may be dangerous. The intestine tolerates the pressure safely for a short time, but continuance for several hours sometimes leads to perforation.

The changes introduced by low temperature and the entire question of the feasibility of refrigeration in the abdomen, require investigation by animal experiments. Observations on cats proved the species to be unsuited for the purpose because of special sensitiveness. The main mass of the experiments were, therefore, performed on dogs, which as usual react more like man.

METHODS

All animals were under nembutal anesthesia. The experiments are divided into low and high abdominal ligations, and these again subdivided into those with closed or open abdomen. These important differences of level in the dog's abdomen are impossible to duplicate with an external tourniquet in man.

For the closed type of experiments, a narrow tourniquet in the form of two or more superimposed turns of a strong elastic rubber tube is applied either close above the pelvis or close below the ribs. In the former case the animal is suspended by the hind legs, in order that the free portion of the intestine may fall toward the diaphragm and thus not be included in the ligation. For application of the high tourniquet the animal is suspended by the forelegs, in order that the main mass of the intestine may be included in the area cut off from circulation.

The hind parts are then buried in crushed ice up to a point an inch or two anterior to the tourniquet. It is possible instead to place the animal vertically in ice-water, but this position involves more strain and greater difficulty in keeping the anterior parts warm. The hair of a dog or cat interferes with chilling or even wetting of the skin. Shaving of such a large area is troublesome and also creates inconvenience in keeping the animal warm after the experiment. Therefore, immediately after application of the tourniquet the hind parts have been rubbed with a solution of green soap just before putting on the ice. The fore parts are covered warmly and also heated by hot water bags or electric pads.

Temperatures have been taken with a long laboratory type of thermometer inserted occasionally into the rectum or esophagus. The endeavor is to keep the parts anterior to the tourniquet at normal temperature, and those posterior to the tourniquet at the lowest possible temperature above actual freezing. No refrigerating blanket or other artificial device can match the close contact of ice or ice-water with the skin; nevertheless the chilling of the large tissue masses is slow and unsatisfactory in the animals and must be still more so in man. In cats the rectal temperatures have approximated 60 to 66°F. (15 to 18°C.) at the end of one hour and 50 to 56°F. (10 to 13°C.) at the end of two hours. The dogs used have been small, about 4 to 8 kg. in weight, and owing to their greater size the temperatures tended to fall a little more slowly than in the cats.

Perfusion with ice-cold Ringer solution or plasma might promise ideal refrigeration, but a few trials indicated that chilled tissues are like dead tissues in resistance to perfusion. A considerable quantity of fluid can be injected slowly into a main artery, but very little of it returns from either the

artery or the vein; also there is very little flushing out of the blood which is known to be locked up in an unclotted state somewhere in the vessels.

Recourse was next had to injections of iced physiological saline intraperitoneally, intramuscularly and subcutaneously. Extreme variations in quantity were tried without establishing an optimum. A dog has been given as much as one-third of its own weight of salt solution, making the abdomen tense almost to bursting, the rectal mucous membrane protuberant and the skin and tissues of the flanks and thighs tightly stretched. The insertion of needles or cannulas does not provide rapid or thorough drainage for such injections. The presence of such a mass of fluid under such tension has not resulted in any noticeable harm at the low temperature. It has not prevented the return of circulation, though theoretically there is a disadvantage in the larger cold mass which must be warmed by the returning blood. Even though the abundant saline may be an aid against shock, there is this added chill of the entire body. Therefore, intraperitoneal injections of 200 to 500 cc. of iced saline have commonly been used in the attempt to reduce the rectal temperature below 50°F. or 20°C. within the first hour. After that the external cold suffices for a further slow and progressive reduction of temperature. Even under the best conditions, the experiments with closed abdomen never furnished the ideal temperatures for preservation of tissue and prevention of shock.

The experiments with open abdomen may be of various kinds and degrees. An incision may be made only large enough for insertion of drainage tubes or to allow injected saline to escape through the wound. Larger incisions anywhere posterior to the tourniquet may serve for approaching different organs or drawing the intestine outside the abdomen. The intestine can thus be freely exposed for operative purposes upon a rubber sheet or in a shallow pan, and can be kept chilled by a jet of iced saline or by Therm-O-Rite applicators.* Under any of these conditions the tourniquet, applied before the incision is made, compresses the abdominal walls to form an effective barrier between the warm and cold parts of the abdomen. A different procedure may begin with a transverse incision; the intestine or other selected organs may then be isolated by ligation with light rubber bands, and the usual heavy tube tourniquet may be carried around the back internally and externally. The upper part of the abdomen can then be walled off with waterproof packing, the hind parts placed on ice or a refrigerated surface, the hind legs covered with ice and the peritoneal cavity chilled by irrigation with iced saline. Although, as already mentioned, it is possible to injure the intestine by too tight or too prolonged tourniquet pressure, thus far no ground for apprehension has been found concerning damage to the aorta or vena cava by the methods described. With any of the open methods, the cold saline irrigation can readily reduce the rectal temperature to 40°F. or 5°C. within one-half to one hour. This method, therefore, provides the most effective chilling that is possible for the trunk.

Another variant consists in chilling the intestine alone, while the body is kept warm. Spreading out the ligated intestine upon a chilled surface or in a pan of cold saline is the method required for practical operations. The commonest experimental plan, however, has been to have the animal lying prone, with the intestine immersed in a jar of iced saline under the belly, while the back is covered warmly and the fore and hind quarters rest on warm surfaces. In the preparation, the abdominal incision is only 2 or 3 cm. long; the small intestine is extruded as completely as possible while the large intestine is usually left inside. Light rubber ligatures have appeared preferable to clamps. The iced saline rises barely above the level of the ligature with the least possible wetting of the belly.

The results will be summarized according to the above mentioned types of experiments.

PELVIC LIGATIONS

A tourniquet just above the pelvic bones may conceivably be needed for hemorrhage, shock or infection below that level. With lesions of the thighs or hips the body cavity may remain closed, but it must be opened for internal hemorrhage or involvement of the pelvic organs.

Besides the fatal shock in rats from application of such a tourniquet for one and one-half to two hours at room temperature,[4] the males die with even shorter periods, such as one-half to one hour, from urinary obstruction and hydronephrosis, while the females survive after a period of dribbling of urine. Paraplegia is severe and temporary; disturbances of defecation slight and temporary. The spinal cord has supposedly retains adequate circulation. protection against tourniquet pressure and That the paraplegia is due to asphyxial degeneration of peripheral nerves seems to be confirmed by its temporary character.

All the above injuries in rats were reduced by refrigeration and the same rules apply in cats and dogs, with some differences of time and details. No tests at room temperature were made in cats. In one cat the tourniquet was applied for two and one-half hours with external icing and no saline injections, so that at the end the rectal temperature had fallen only to 54°F. or 12°C. There was an easy recovery with only slight and transitory weakness of the hind legs. Incisions to permit irrigation of the pelvis with iced saline did not improve the results, as one cat recovered with transitory partial paralysis after a three-hour ligation while another died in forty-eight hours after a two and one-half-hour experiment. In general the increased efficiency of refrigeration seems to be more than counterbalanced by the special sensitiveness of the peritoneum in cats.

In one dog, a tourniquet above the pelvis for one hour at room temperature resulted in severe paraplegia which cleared up almost completely in three weeks. In another dog a three-hour ligation was followed by complete paraplegia which has persisted without important improvement for two months. Regeneration of nerves will presumably require longer time in the dog than in the rat, and the later result or autopsy must show whether the spinal cord was involved.[*] The degree of shock was dangerous, and especially in view of the prominent factor of paraplegia it seemed unprofitable to go on to learn the time limit required for actual death.

In similar experiments, the external application of ice decidedly reduced all forms of injury, and injections of iced saline without surgical incision improved the results further. In this way ligations above the pelvis for one to three hours occasioned only slight disturbances. The longest tourniquet application was for six and one-fourth hours; the dog recovered easily but had very marked weakness of the hind legs which passed off almost completely in three weeks. Though this was evidently not the maximum endurable time limit, it seemed sufficient and no longer experiments were undertaken.

A few experiments of two to three hours were performed with incisions exposing the pelvis more or less widely for examination and saline irrigation. The results were broadly similar to the preceding though exact comparisons were not made. The main point was that the best possible refrigeration did not abolish all injury. The prostration, even if brief and slight, could probably be interpreted as true shock, though no tests concerning its nature were performed. Also some degree of weakness of the hind legs was never

[*] After three months of practically unchanged paralysis the dog was killed for autopsy. Cursory microscopic examinations revealed no obvious changes in the spinal cord or sciatic nerves. Evidently, therefore, the intraspinal blood supply is sufficient to prevent any gross degenerations during three hours without refrigeration. It remains for special staining and study to determine whether any fine changes in the nervous tissue can be found or whether the persistent paraplegia must be classed as functional.

entirely preventable. Both the local and the general weakness were increased either by lengthening the individual experiment or by repeating the ligation at intervals of a few days in the same animal. In cats and dogs, the disturbances of urination and defecation were always slight, even with ligations at room temperature. Temporary diarrhea was usual and in the severest experiments it might be mixed with blood.

Man is more susceptible than the dog and cat to edema and perhaps also to nerve injury; therefore, abdominal ligation may perhaps cause temporary disturbances of urination in the form of either bladder paralysis or prostatic swelling, along with more or less paresis of the legs. The main lessons of the dog experiments, however, seem to be: first, that the general injury from pelvic ligations and refrigeration in normal animals is so slight that the procedure may be considered feasible when necessary in weak or shocked human patients; second, that the pelvic organs tolerate refrigeration excellently and that no permanent damage to them need be feared at least with ligation periods up to six hours.

REFRIGERATION OF ISOLATED INTESTINE

Previous experiments[5] showed that the chilled intestine can remain viable for long periods without circulation. For example, a small loop was thus preserved for sixteen hours with no indication that this represented the utmost time limit. During refrigeration the intestine retains firm texture and approximately normal color. After restoration of circulation it flushes a clear pink and is strikingly healthy in appearance without any suggestion of necrosis.

Notwithstanding this excellent preservation of tissue, refrigeration of the whole or any large portion of the small intestine proved fatal in cats. That this was not due to specific functional disturbances in the upper bowel or feces or bacteria in the lower bowel was proved by the equally fatal result when either the upper half or the lower half of the bowel length was refrigerated. The condition was evidently not mere shock, and the severe secondary type of anemia developing in the rare animals which lived as long as a week suggested the possibility of a functional disturbance in the liver resulting from the chilling. The present experiments, limited to five cats, confirmed the occurrence of death within twenty-four to forty-eight hours after refrigeration of the small intestine for periods as short as one-half to one hour. Fasting for two or three days before the experiment did not save the animals. In one instance the intestine was warmed with warm saline immediately before and after removal of the ligature; this animal lived three days to die of peritonitis, but there was no further trial of this kind in cats.

It was unfortunate that circumstances limited the previously published experiments to small animals, because they tended to confirm prevalent preconceptions concerning the danger of chilling any peritoneal organs. The opportunity to use dogs immediately disproved the greater part of these fears regarding the intestine. After occasional early fatalities from flaws of technic, it soon became evident that efficient chilling allows dogs to survive two or three hours of ligation of the entire free portion of the intestine and to appear as well the next day as after a simple laparotomy. With practice the time has recently been extended to five hours, and it is not known whether this limit is uniformly safe or whether it can be extended still further by better technic.

These are the results obtained with the dog in the prone position and the intestine hanging down into a jar of iced saline, involving no trauma during refrigeration beyond the slight stirring needed occasionally to assure penetration of cold among the intestinal coils. Although a statistical comparison is lacking, there have been poorer results with the animal supine in the usual operative position and the intestine drawn out on a cold surface or in a pan of

cold saline. Fatal accidents have been more numerous, prostration greater and the safe period apparently limited to two or three hours. These difficulties are perhaps largely explainable by less thorough chilling and avoidable by better technic. It is necessary also to consider two factors which may set definite limits to intestinal refrigeration:

1. *Enteritis.* The beautiful rosy flush of the intestine after release of the ligature passes on into a reactive inflammation. This seems to be a direct consequence of the low temperature, even when the bowel has not apparently suffered from anoxia. It becomes more severe with increased duration of the refrigeration and is not preventable by any means yet known. There is also an influence upon the portion of the bowel not ligated, because some diarrhea usually begins during the ligation and in long experiments is mixed with blood. While shock may be admitted as a temporary factor, the dominant element of enteritis is established by examination of the bowel and by the continuance of diarrhea or melena for several days or, in severe cases, weeks. The intestine is typically smooth, shining gray on its peritoneal surface and deep dark red with congestion and hemorrhage in its mucosa. A discharge of blood and mucus may mix with the intestinal contents, or sometimes there may be light brown fluid in the lumen while a fibrinous bloody exudate clings to the wall. The feces may present various appearances of bloody diarrhea, or sometimes take the form of granular masses of blood and fibrin closely resembling sausage. Doubtless connected with this enteritis is the sometimes striking anorexia. An extreme example was a dog which wagged his tail cheerfully, ran around with fair liveliness, and showed no symptoms except slight weakness, diminishing diarrhea and complete refusal of food for nearly three weeks, after which he recovered completely.

2. *Shock.* There are plain indications that the chilled intestine is not immune to injury and shock. Actual intestinal operations have not been included in these experiments, but the intestine has been spread out and handled more or less roughly for various periods to imitate examination and test the influence of trauma. This extra handling is believed to account partly for the poorer resistance of animals experimented upon in the supine as compared with the prone position. Reflection shows that this result is not out of harmony with the absence of shock in operations on refrigerated limbs. During ligation and refrigeration, no trauma to limb or intestine produces any constitutional effect. If damaged tissues are left in a limb after operation, the absorption of their products causes the usual shock effects. The intestine is composed of softer and more vulnerable tissue than a limb, and handling or other trauma leaves minute lesions. Such lesions distributed throughout the length of the intestine can produce a large shock effect. Refrigeration seems nevertheless to increase the resistance of the intestine to trauma and shock, and this result may be explained theoretically both by the suspended animation due to low temperature and by the firmer consistency.

The harmful effects have been described with emphasis upon their most extreme manifestations under the severest tests. The main information from the experiments, however, is that the entire free portion of the intestine can be kept outside the body at a temperature near freezing during the length of time required for any ordinary operation, with practical safety as regards local and general consequences.

HIGH ABDOMINAL LIGATIONS

The placing of a tourniquet close under the rib margin is the most formidable undertaking in this series, because it includes stoppage of circulation in an increased mass of trunk tissues and the intestine simultaneously.

Accordingly, the time limits are shorter than with the procedures previously described. As an exception, one cat recovered

after such a ligation for one and one-fourth hours, but others have died from shock or cachexia after experiments of only one hour. The longest refrigeration with closed abdomen from which dogs have permanently recovered has been three hours. This period can probably be extended by better technic but an absolute limit is probably set by two factors: First, with the blind application of an external tourniquet there is always the chance of pinching the intestine in such a way that a strangulated loop projects into the warm part of the abdomen above the tourniquet, and as long as there is the possibility of such an accident the ligation period cannot safely be extended beyond the survival limit of such an isolated loop. For example, in one dog which died after a high ligation of 4½ hours nearly the whole intestine, large and small, showed only the usual inflammatory reaction, but a small segment of the transverse colon was necrotic from strangulation where it had been shut off from both blood supply and refrigeration. Second, this procedure is followed by all the symptoms previously described, notably enteritis and shock. Thus, one dog subjected to high abdominal ligation for five hours died within ten hours, with profuse bloody diarrhea and the typical appearance of shock. There is ample reason for shock in the large mass of asphyxiated tissue and the imperfect refrigeration.

In comparison with these experiments with closed abdomen, the surgical opening of the abdomen offers two apparent advantages, namely, the more accurate placing of the tourniquet to avoid accidents and the more rapid and efficient chilling. Nevertheless, the actual results thus far have been inferior to those with a closed abdomen, the prostration being greater, the mortality higher and the maximum time limit with complete recovery only two and one-fourth hours. The effects are slightest when the abdomen is merely opened and the intestine left undisturbed except for the cold saline irrigation, and with further attempts along this line the above stated results could probably have been bettered. The great majority of the experiments included spreading out the intestine and handling it crudely during the refrigeration and the injury thus produced evidently more than counterbalanced the more thorough chilling.

These findings show that the drastic chilling of nearly one-half of the total body mass, including almost the entire intestine, is a radical procedure involving shock and other injuries. Formal tests to prove the reduction of shock by refrigeration were omitted as superfluous. Two facts deserve practical attention: First, simple inspection of the intestine, and also the far slighter paraplegia, furnish a sufficient demonstration that, in any case in which complete stoppage of the abdominal circulation by tourniquet or otherwise is found necessary, the danger and harm can be diminished by reduced temperature. Second, the ability to spread out the entire free intestine outside the abdomen, and the comparatively slight disturbance resulting from refrigeration of the entire lower part of the body for limited periods such as one hour, may have possible usefulness for operative purposes in certain desperate cases, especially if the technic is further developed.*

* More recently, it has been attempted to use rabbits for tests of the practical application. Fatal degrees of shock were produced by either (a) dipping the hindquarters of the anesthetized animals in boiling water for a definite time, such as thirty seconds, or (b) placing tourniquets on both hind legs for seven or eight hours. An extreme illustration of primary shock was found in the experience that lightly anesthetized rabbits often react to an extensive brief burn by a convulsive reflex jerk and death within a few seconds. Treatment of secondary shock was attempted by applying an abdominal tourniquet, refrigerating the hind parts, and finally amputating the hind legs. Except for holding symptoms in abeyance while the tourniquet was in place, the outcome was failure, since deaths were more numerous or earlier among the animals operated upon than among those untreated. As regards the practical interpretation, it is recognized that an abdominal tourniquet causes some shock under any conditions; it can only be useful if it permits doing something important enough to be worth the temporary added injury; the rabbit is apparently too delicate to furnish a reliable criterion of human resistance; and nothing invalidates the main fact that if an abdominal tourniquet is to be used, all the harmful effects of it are reduced by lowered temperature.

MISCELLANEOUS OBSERVATIONS

1. *Upper Abdominal Organs.* Although it might be physiologically interesting to exclude the liver from the bodily economy for a number of hours and then restore it unharmed, such an attempt seems theoretically unpromising. The entire dangerous region of the upper abdomen and the vital organs contained in it are outside the grasp of the tourniquet placed below the rib margin. An experiment including this region was performed upon one dog. Through a curved incision below the rib border, a tourniquet of light rubber bands was placed above the liver, and behind it a heavy tourniquet was carried around the back. With all circulation below the diaphragm thus blocked, while the head and thorax were warmed, the lower part of the body was iced as usual and the entire peritoneum flooded with a current of cold saline. Feeble heart action and slow respiration continued for twenty minutes and then ceased. The tourniquets were quickly removed and refrigeration stopped. Artificial respiration soon restored the pulse but it was ten minutes before spontaneous breathing returned. Excellent heart action and respiration then continued for one-half hour, but after the incision was closed and the danger seemed past the animal suddenly died and gave no response to artificial respiration.

Regardless of the feasibility of chilling individual organs such as the kidneys,[6] stomach or spleen, there appears to be no prospect of safe refrigeration of the liver or of the upper abdomen in general. The rib margin appears to be the highest practicable level of ligation for this purpose. Even in the experiments with intestinal refrigeration, the harmful or fatal effects have apparently been less when the incision was made in the middle or lower abdomen rather than near the ribs where some chilling might be transmitted to the liver and adjacent organs.

2. *Optimum Refrigerating Temperature.* Many incidental observations leave no doubt that local and constitutional dangers are increased in proportion as the temperature is raised above freezing, or at least above 5°C. The intestine furnishes excellent opportunities for tests. No lesions suggestive of frostbite or harmful effects of any kind have been noticed with any temperatures short of actual freezing. One formal comparison was made with refrigeration of the isolated intestine for four hours within a range of 1° to 5°C. in one dog and 15° to 20°C. in another dog simultaneously. In the former case the intestine showed good color throughout the ligation and a prompt bright flush on release, and the dog easily recovered. In the latter animal the ligated intestine developed a deep blue color, the change to pink required a couple of minutes after release, and acute death followed evidently from shock. At the same time it is clear that a reduction even around 20°C. or 70°F. greatly reduces local and constitutional injury as compared with normal body temperature. There is also an interesting picture of the mesenteric veins which are full of blood but remain unclotted practically indefinitely at a sufficiently low temperature. The time required for intravascular thrombosis might serve as a measure of the efficiency of tissue preservation at different temperatures, though the level of 20°C. still suffices to prevent this process for at least five hours.

3. *Refrigeration without Tourniquet.* One rather weak dog was placed in the prone position, with the entire free intestine hanging down into iced saline and with the rest of the body well warmed, in exact reproduction of the standard procedure except that the ligature on the intestine was omitted. Strong pulsations in the mesenteric arteries made visible fluctuation of the saline solution, but in only five minutes the dog died quietly, when the rectal and esophageal temperatures had fallen only to 96°F. Even if a stronger animal might have survived a little longer, the result substantiates the traditional apprehension of surgeons concerning peritoneal chilling, and illustrates the indispensability of the tourniquet not only for

maintaining sufficiently low local temperatures but also for saving life. The reason for the early death, whether chilling of the liver, nervous reflex, or anything else was not investigated.

4. *Temperatures after Tourniquet Release.* During refrigeration of any part, the general bodily temperature has sometimes been kept normal and sometimes has fallen to 90°F. or even lower. Upon release of the tourniquet the cold and wet parts have customarily been dried and warmed to variable degrees. In proportion to the extent of the refrigerated area, there is a fall of general body temperature after release, sometimes to 80°F. or lower, with accompanying symptoms. If the animal has been almost at the point of waking up, the fall of temperature following release of an abdominal tourniquet is likely to cause a lapse into total unconsciousness. There is danger in allowing too low temperature or too deep unconsciousness just before release because death may result. It is only remarkable that the pouring of warm blood into ice-cold regions and the return of chilled blood to the heart and other organs are as a rule so easily and safely tolerated, especially when the cold part may approximate one-half of the total body mass and the chilled portal blood must cool the liver sometimes for several hours.

The numerous but scattered observations have not afforded a precise conclusion concerning the central question of treatment at this stage, namely whether the tissues should be allowed to recover normal temperature gradually, and to what extent rapid artificial warming is beneficial or harmful. Obviously, the temperature must become normal within a reasonable number of hours, since "cold and exposure" stands as a recognized medical cause of death. On one hand it is easy to confirm Temple Fay's observations on artificial hibernation, in that dogs may remain unconscious with extremely low temperatures for six hours or more and still appear surprisingly well the next day. On the other hand there is agreement with Blalock's[7] decision that no

degree and no duration of reduced temperature saves an animal from death in shock. Empirically, it has finally seemed best to warm the animal promptly and carefully but not to try to force the temperature immediately up to full normal level. The difference seems to be not a major one as regards the peripheral tissues because it is doubtful if any animal has actually died or been saved through changes of general temperature within the limits in question. The difference in regard to the intestine may be more important. The above described observations in paragraphs two and three have seemed to create a rather sharp distinction, namely, that the optimum temperature during ligation is as near to freezing as possible, and the optimum temperature without ligation is as near to normal as possible. Therefore, it has been the preferred procedure recently to begin flushing the intestine with warm saline, so as to raise its temperature somewhat for perhaps one minute before release and to continue this flushing so as to assist in the quick recovery of normal temperature after release of the ligature. According to the present impression, this plan is somewhat beneficial.

5. *Osmotic Influences.* One of the most prominent occurrences after prolonged intestinal refrigeration is a profuse blood-stained exudation. A forerunner of it may be seen in the pink staining of the saline solution during refrigeration, often with visible red corpuscles and small fibrin shreds. It is necessary to estimate the importance of either osmotic injury of permeability or diffusion of vital elements out of the tissues during refrigeration in the quest for needed improvement of technic. Comparisons have shown that the intestine can survive immersion in plain ice water for considerable periods, but the resulting inflammation is severe and in prolonged experiments may be fatal. Neither physiological saline nor Ringer solution prevents these results altogether. The importance of the colloid factor was shown by two experiments with saline-gum arabic solution as

marketed for transfusion purposes. In these two instances there was a practically complete prevention of the bloody exudation both during and after refrigeration. Therefore, in this respect either the gum solution or actual plasma may be considered the ideal medium. Nevertheless, from a practical standpoint this appears to be a minor consideration. The peritoneal exudation is unconnected with the more serious enteritis which is manifested in the bloody diarrhea, and this latter is not greatly affected by the use of either Ringer or gum-saline solution. In the laboratory accurate conclusions require exact conditions, and these are provided by one of the above mentioned media in a container which is either set in a freezing mixture of salt and ice or more uniformly chilled by metal tubes connected with a Therm-O-Rite apparatus. But it must always be remembered that wounds of the desperate nature envisaged in this investigation must usually be treated under emergency conditions, and a method requiring laboratory precision could have only limited practical usefulness. Therefore, an opposite set of conditions is presented by saline solutions made up crudely with a flat teaspoonful of table salt per pint of mixed tap water and ice, all chance of isotonicity being spoiled by the melting of the ice. All the results heretofore described are obtainable with a makeshift mixture of this kind. In fact, an added feature of the comparative experiment described in paragraph two was that the test at higher temperature was made with carefully prepared gum-saline solution, while the one at lower temperature was made by guess as just described. The general conclusion on this point is that while the best possible osmotic adjustment is desirable, it is of trivial importance in comparison with efficient temperature reduction, and that satisfactory practical results are obtainable with salt solution of crudely approximate composition.

6. *Intestinal Perforation.* Occasional deaths have occurred from intestinal per-

foration several days after the experiment, when shock was over and the animal appeared to be in good condition. These deaths become more numerous as the duration of refrigeration is increased. The uniform autopsy finding is that nearly all of the intestine is perfectly preserved. The peritoneal surface is gray, smooth and glistening. The bowel lumen contains brownish liquid, and after sufficiently severe experiments the congested mucosa and bloody exudate are as previously described. The bowel wall is firm and contracted but never spastically so as to cause obstruction, and it has a characteristic turgid consistency. Along the extensive, well preserved coils may be seen a few small ulcerated areas, some amounting to nothing more than an abrasion of the serous surface, others exposing the muscular layers to different depths, and one or possibly two containing a perforation 1 to 5 mm. in diameter. The known danger spots of pressure by clamps or tourniquet, or pinching of the intestine between the body and the saline container, can be recognized, but the ulcers described are at other places. They have seemed to be identifiable as the result of direct contact of the bowel with ice. The combined thermal, pressure and osmotic effects, also the possible cutting by sharp edges, can be safely tolerated for a time, so that perforation is rare with refrigeration of one to two hours but becomes more frequent after periods of four or five hours. This is, therefore, one of the forms of trauma requiring precautions.

7. *Infection.* The desirability of asepsis is too obvious for comment, but industrial and military wounds of the kinds here under consideration commonly involve the grossest contamination of the peritoneum with foreign dirt or the contents of ruptured intestines. When, as in the present experiments, all the manipulations are carried out by a single individual, there is difficulty in maintaining asepsis. Accordingly, for this reason and for imitation of the most primitive clinical conditions, all the above described experiments were per-

formed without any aseptic care, aside from shaving of the immediate wound area. There was no preparation of hands or instruments. The intestine was spread out on nonsterile surfaces or in saline with ice containing visible specks of dirt, and sometimes was unintentionally or intentionally smeared with loose hairs or other foreign matter. When any such material is shut up in the peritoneum, fatal peritonitis always results; but if it is washed off with cold salt solution which is filtered but not sterilized, there is usually no harm beyond the slight trauma involved in the washing. The final brief flushing with warm saline, as described in paragraph four, does not reduce the safety because the peritoneal adhesiveness is not immediately restored. To gain an impression of the transformation created by refrigeration, it is well for the orthodox surgeon to convince himself by trial that he can operate in this manner and seldom encounter peritonitis. The reason may be conceived as largely mechanical. The chilled peritoneum immediately loses all its characteristic adhesiveness. In this state it offers a glassy smooth surface, and contrary to traditional surgical teaching, both the visceral and the parietal peritoneum can be washed clean. Tests of absorption would be of interest, because they might show changes away from specific protoplasmic absorption in the direction of freer nonvital diffusion; but at present it may be assumed that chemotaxis and penetration by bacteria are totally inhibited. Granting cleanliness to the extent of absence of solid foreign particles, the normal resistance of the peritoneum perhaps suffices to dispose of any remaining bacteria. There is a conceivable possibility of further hypotheses as, for example, that the bacteria quiescent from cold may be phagocyted in the returning rush of warm blood before they can recover their defensive mechanisms; but any such speculations must find support in the remarkable subsidence of infection in refrigerated limbs rather than in anything thus far demonstrated in the peritoneum. The incidence of peritonitis

seems to increase with the duration of refrigeration, and this fact strengthens the suspicion that these infections begin in the areas injured by ice or other trauma rather than in the intact portions. It is questionable if the dog's peritoneum has any higher resistance than the human. The experiments without asepsis appear to warrant two principal deductions: first, that tissue vitality and resistance to infection are at least not reduced by refrigeration; second, that some possible advantages are offered for certain desperate cases with gross contamination of the peritoneum.

8. *Adhesions and Peritoneal Reactions.* As previously noted,[5] peritoneal areas injured in the course of refrigeration finally form adhesions, usually slight in extent and density. The tendency to adhesion formation is inhibited not only during refrigeration but to some extent for several days afterward. The question is, therefore, open concerning possible usefulness in preventing troublesome adhesions in limited locations. During this same period, characterized by the contracted and turgid state of the bowel, there is another question of altered absorptive and reactive properties in the peritoneum. It may be significant that none of the peritonitis cases in this series showed a rectal temperature higher than 102°F. (a barely appreciable elevation over the dog's normal range), and as a rule the course of temperature was subnormal. This peculiarity seemed scarcely explainable by the type of infecting organisms, as it occurred also with intestinal perforation, or by excessive prostration, because the general strength and the survival period of three to six days were equal to the average for dogs with general peritonitis. Such a temperature curve may also accompany peritonitis in dogs without refrigeration; but if the febrile tendency is reduced by refrigeration, there has at least been no sign of benefit for saving the lives of the animals.

9. *Treatment.* A few observations indicated that abdominal ligation and refrigeration are more dangerous shortly after

eating. It is impossible that emergency human cases should be prepared by fasting a day or two in advance like the dogs, but on the other hand therapeutic means such as the stomach tube were not used for the animals. Other considerations of treatment pertain to shock and infection. The occurrence or prevention of an abundant bloody peritoneal exudate seemed to have no decisive influence on the state of shock such as might be expected under the physical theory. Several saline irrigations to wash out the fluid on the chance that it might contain tissue poisons causing shock were equally negative for support of the toxic theory. Saline infusions were the only treatments used for shock, in continuance of the previously expressed view[4] that hemorrhage and shock, though often connected, are primarily distinct, and that the need in the former is for a fluid which will remain in the vessels but in the latter is mostly for an abundance of fluid which can readily escape from the vessels.

No treatment was used for peritonitis beyond a few trials of refrigeration. Washing the peritoneum with iced saline, with or without a tourniquet, can clear away pus and induce a clear bright hyperemia, but instead of being beneficial it seems rather to hasten death. The value of Temple Fay's prolonged crymotherapy for local infections is not here in question because it is a different process. The only known value of the temporary extensive refrigeration here described is for cleansing and checking potential infections. The previously mentioned inhibition of adhesions may be detrimental under some conditions, by preventing walling off and localization of infection, but under other conditions it may offer remarkable opportunities for drainage and irrigation. In the limbs, the wound edges adhere almost as soon as the temperature is raised, but the adhesiveness of the peritoneum remains inhibited after warmth is restored even during several days. The conditions of tissue resistance, absorption, drainage, irrigation and local chemotherapy remain to be investigated

with reference to the treatment either of ordinary peritoneal infections or of dangerously contaminated wounds after refrigeration.

PATHOLOGICAL OBSERVATIONS

All the pathological studies of the refrigerated intestine were made by Dr. W. E. Youland. The reports on all animals stated that on gross examination the bowel was white and markedly contracted; the three coats were clearly recognizable and intact except as otherwise mentioned.

DOG 1. A tourniquet was applied below the ribs for five hours, with the abdomen opened. Refrigeration with ice and iced saline produced rectal temperatures of 68°F. in one-half hour, 56°F. in one hour, 46°F. in one and one-half hours, 44°F. in two hours, 40°F. in three hours, and 38°F. at the end, with esophageal temperature 98°F. After removal of the tourniquet the temperatures in one-half hour were 80°F. rectal and 85°F. esophageal; in one hour 88°F. rectal and 94°F. esophageal; in two hours 95°F. rectal and 96°F. esophageal. Death occurred apparently from shock seventeen hours after removal of the tourniquet and the autopsy was performed within two hours. Grossly, the intestinal coils were gray, shining and turgid as usual. Dr. Youland's microscopic report was, in summary, as follows. It seems to agree with the interpretation of the origin of infection in damaged areas:

The specimen of small intestine appears structurally intact. The lumen is filled with cross sectioned glandular tissue so that no actual lumen is seen. The mucosa appears markedly thick and consists of closely packed long tubular glands separated by barely visible fibrocapillary tissue. Underlying them is a thin layer of loose fibrillar tissue containing a moderate number of mononuclear cells. The appearance of the epithelium and goblet cells indicates a "resting" stage of the mucosa.

The muscularis mucosae and outside of it the inner longitudinal and outer circular muscle layers are thick and contain numerous markedly dilated capillaries. The nervous structures appear normal.

The serosal endothelium shows hyaline thickening in some places. Otherwise it is generally normal.

Some sections show collections of apparently intact lymphoid tissue, free from discoverable cytological or cytonecrotic changes.

In one microscopic section the serosa shows a markedly thickened layer of hyaline material which, at the surface, stains poorly with eosin. There are numerous clumps of cocci upon the surface of, and imbedded in this hyaline material. The muscle tissue underlying this area shows marked atrophy of the fibers with a possible edema of the interspaces.

One microscopic area shows necrosis of the serosal endothelium. The remainder of the serosa in this section is intact.

Another section of the intestine shows rather extensive edema of the subserosal layer with fibrin formation, slight to moderate mononuclear cell infiltration, hyaline fraying of the serosa with here and there a clump of bacteria.

The attached mesentery shows numerous large and small blood vessels. These appear intact and normal throughout. There is no evidence of any thrombosis. The smaller capillaries show extreme dilatation and engorgement with red blood cells.

Dog 2. A high abdominal tourniquet (just below rib margin) was applied for three hours, while the soaped parts posterior to it were buried in ice. The esophageal temperature was kept at 96 to 98°F. throughout. After one hour the rectal temperature had fallen only to 74°F. Intraperitoneal injection of 300 cc. iced saline reduced it within ten minutes to 64°F. At the end of two hours it was 52°F., and after the third hour 50°F. The unconsciousness, already unduly deep, became profound after removal of the tourniquet, and the eye reflex remained absent during five hours of subsequent observation. At the end of this time the pulse was 66, respiration 20, esophageal temperature 88°F., rectal 86°F., with bloody diarrhea in progress. Seven hours later (twelve hours after release of tourniquet) the dog was found dead but quite warm, showing that death had been very recent and also that something like normal temperature had been regained.

In the various microscopic sections, the closely packed glands of the mucosa showed various degrees of mucous hypersecretion, also extreme congestion of capillaries at their tips. Otherwise all three coats were intact.

Dog 3. A transverse incision was made across the upper part of the abdomen. A tourniquet of light rubber bands was placed about the intestine, and behind it a heavy tourniquet was passed around the body. The posterior parts, including the peritoneum, were packed with ice and flooded with ice-water. There was no embarrassment of breathing, such as occurs with a tourniquet around the closed abdomen. The esophageal temperature was down to 90 to 92°F. during most of the time. Nevertheless the first part of the treatment was inefficient, so that the rectal temperature was reduced only to 72°F. in one hour. It was then rapidly lowered to 56°F., and was 50°F. at the end. The duration of ligation was two and one-fourth hours. With the usual external heat applications both esophageal and rectal temperatures rose slowly, and three hours after removal of tourniquets they were 94° and 84°F., respectively. Twelve hours later the dog was found dead and cold, with blood tinged fluid filling the abdomen. The intestine was mostly pale and firm as usual, but in some places was pink and slightly soft, presumably from direct contact with the ice. On section, a thick bloody exudate was found sticking close to the reddened mucosa.

The microscopic findings were extensive superficial autolysis of the mucous membrane, marked mucous hypersecretion of the remaining glands and intact muscular and serous coats.

Dog 4. The body was swathed in a sheet of rubber dam, which was sewn to the edges of the skin wound. Through the small incision in the upper portion of the abdomen the entire free portion of the intestine was extruded, ligated and immersed in isotonic gum arabic-saline solution for four and one-half hours. The rectal and esophageal temperatures were easily kept normal, but the chilling of the intestinal bath was inadequate. Ten hours after removal of the ligature the dog was found dead with no exudate in the peritoneum.

Microscopically, a slight superficial autolysis in some mucosal areas was interpreted as probably a postmortem digestion. There were a few points of trivial inflammation in the serous coat. Essentially, the findings were normal in all three coats.

CONCLUSIONS

Discarding cats as unsuitable, the following conclusions are based on experiments with dogs:

1. Refrigeration permits stoppage of circulation by a tourniquet or ligature in the region of the abdomen to be tolerated without fatal injury for considerable periods; for example, more than six hours with stoppage just above the pelvis, three hours with stoppage just below the rib margin and five hours with ligation of the entire free portion of the intestine alone. Large injections and irrigations of iced saline solution are a harmless and valuable aid in the refrigeration of such large tissue masses.

2. The entire condition and technic need to be further studied and developed, but at present the most important known considerations for safety are efficient chilling to the nearest possible point above freezing, avoidance of trauma, and minimal time of operation, while osmotic and aseptic niceties are secondary. Along with the excellent preservation of tissue vitality, probably the most striking feature is the small risk in operating without asepsis and the effective cleansing of the peritoneum by iced saline flushing.

3. The abdominal tourniquet being not unknown in surgery, the gist of this investigation is that low temperature greatly reduces local and constitutional injuries and dangers, the chief of which are shock, paraplegia and enteritis. These bad effects are not wholly prevented, and this radical method is not calculated to replace ordinary surgical usage under ordinary circumstances. It appears worthy of clinical trial in conditions and emergencies which are otherwise hopeless, for example, in the severest hemorrhage, burns and wounds of the lower part of the body. The procedure is most promising when limited to the hips and pelvis, reasonably hopeful if a damaged intestine can be refrigerated while the body remains warm, and most difficult if approximately half of the total body mass must be refrigerated along with the intestine. Granting a high mortality among these cases which are inoperable by any other method, such an experience especially in traumatic and military surgery can furnish a decisive evaluation of refrigeration in the abdomen.

REFERENCES

1. ALLEN, F. M. Local asphyxia and temperature changes in relation to gangrene and other surgical problems. *Tr. Ass. Am. Phys.*, 52: 189–194, 1937.
   ———. 1. Surgery of limbs. Reduced temperatures in surgery. *Am. J. Surg.*, 52: 225–237, 1941.
   CROSSMAN, L. W., RUGGIERO, W. F., HURLEY, V. and ALLEN, F. M. Reduced temperatures in surgery. 11. *Arch. Surg.* (to be published).
2. McELVENNY, R. T. The effect of cooling traumatized and potentially infected limbs. *Surg., Gynec. & Obst.*, 73: 263–264, 1941.
3. FAY, T. Clinical report and evaluation of low temperature in treatment of cancer. (Also earlier papers.) *Proc. Internat. Assemb. Inter-State Post-Grad. M. A. North America*, 292–297, 1941.
4. ALLEN, F. M. Physical and toxic factors in shock. *Arch. Surg.*, 38: 155–180, 1939.
5. ALLEN, F. M. Ligation and refrigeration of intestine. *Surgery*, 3: 893–898, 1938.
6. ALLEN, F. M. The tourniquet and local asphyxia. *Am. J. Surg.*, 41: 192–200, 1938.
7. BLALOCK, A. and MASON, M. F. A comparison of the effects of heat and those of cold in the prevention and treatment of shock. *Arch. Surg.*, 42: 1054–1059, 1941.
8. BROOKS, B. and DUNCAN, G. W. Effects of temperature on survival of anemic tissue. *Ann. Surg.*, 112: 130–137, 1940.
9. ———. Ibid. The influence of temperature on wounds, 114: 1069–1075, 1941.
10. ALLEN, F. M. Mechanical treatment of venomous bites and wounds. *South. M. J.*, 31: 1248–1253, 1938.
    Observations on local measures in the treatment of snake bite. *Am. J. Tropical Med.*, 19: 393–404, 1939.
11. Ibid. Ligation and refrigeration of intestine. *Surgery*, 3: 893–898, 1938.
12. Ibid. Experiments concerning ligation and refrigeration in relation to local intoxication and infection. *Surg., Gynec. & Obst.*, 68: 1047–1051, 1939.

CLINICAL AND ANATOMICAL INVESTIGATIONS OF DEEP FASCIAL SPACE INFECTIONS OF THE HAND

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INFECTIONS of the deep fascial spaces of the hand present a most serious surgical problem. An accurate knowledge of the fascial distribution of the hand is basic for the proper treatment of deep fascial space abscesses.

Some recent work is contradictory of the more universally accepted facts. Brickel[1] describes the palmar foyer and the adductor space. He describes the palmar foyer as a triangular-shaped cavity. The floor of the foyer is formed medially by the two medial volar interosseous muscles and fascia, and laterally by the adductor pollicis muscle with its fascia. The roof of the cavity is the palmar fascia whose marginal septum on the ulnar side blends with the fascia of the short muscles of the little finger and dips into the groove between them and the fifth flexor sheath. On the radial side, the edge of the palmar fascia blends with the fascia of the adductor muscle to form the radial wall of the first lumbrical canal. The proximal portion of the palmar foyer is a common cavity, enclosing the profundus and sublimis tendons with the radial and ulnar bursae and the origins of the lumbrical muscles.

Distally, toward the metacarpophalangeal joints, septa arise from the deep surface of the palmar fascia, and blend with the walls of the tendon sheaths, separating the tendons from the lumbrical muscles. Proximal to the terminations of the flexor tendon sheaths, these septa blend with the fascia of the interossei and fascia of adductor pollicis muscle for varying distances but never so far as the carpal tunnel. Between the carpal tunnel and the proximal end of the fibrous tendon sheaths, the concavity of the palm is a common space clear from side to side, so that it is possible to pass an instrument across the palmar floor under the flexor tendons. It cannot be done more distally in the palm because of septa from the palmar fascia. The apex of this triangular palmar foyer points into the carpal tunnel. The distal part of the cavity is occupied by the lumbrical canals, tendon retinacula, associated with the septa which pass from the deep aspect of the palmar fascia to the fascia and ligaments forming the floor of the palm.

Brickel states that he has never seen a septum of fascia running from the palmar fascia to the middle metacarpal bone. Brickel describes the adductor space as a fascial space in which the floor is formed by the adductor pollicis muscle. The roof is the fascia of the adductor pollicis muscle. The fascia proper of the adductor pollicis continues over the lateral edge of the muscle. The fascia of the adductor pollicis also forms part of the floor of the palmar foyer. However, the lateral part of the adductor pollicis muscle is separated from the palmar foyer. Brickel states that in all his dissections and injections he never found a special palmar septum, extending from beneath the flexor tendons to the middle metacarpal bone, dividing the palmar foyer in halves. Thus, he states it is justifiable to discard the concept of middle palmar space in favor of a broader interpretation of its boundaries, and to discard the term thenar space in favor of the term adductor space, anterior and posterior.

Kanavel[2] describes the mid palmar space and the thenar space. He states that the midpalmar space lies in the palm, is bounded on the radial side by the fascia attached to the middle metacarpal bone,

on the ulnar side by the hypothenar eminence, distally it extends to within a thumb's breadth of the web, and proximally to the base of the palm. It lies upon the fascia covering the interosseous muscles, and its superficial covering is formed by the flexor tendons and palmar fascia. It is in direct communication with the lumbrical canals between the little and ring and the ring and middle fingers. The thenar space lies on the radial side of the middle metacarpal bone upon the adductor pollicis muscle; superficial to it is the palmar fascia and flexor tendons of the index finger. On the radial side it approaches the surface between the metacarpal of the thumb and index finger. It is limited distally by the deep transverse fascia, one thumb's breadth proximal to the web, and proximally by the base of the palm. There is a definite fascial septum from beneath the flexor tendons of the midfinger with its deep surface fusing with the fibrous tissue overlying the middle metacarpal bone which separates the thenar space from the midpalmar space.

METHODS

Three methods were used in the investigation of the deep fascial spaces of the hand: (1) Clinical study of deep fascial space infections of the hand; (2) anatomical dissection of hands with especial consideration of the fascial distribution; (3) injection of radiopaque material into the fascial spaces and x-ray study.

1. *Clinical Study of Deep Fascial Space Infections.* One hundred cases of deep fascial space infections of the hand were studied at the Boston City Hospital. This study was of value in determining the localization and course of infection in the deep fascial spaces of the hand.

2. *Anatomical Dissection of Fascia of the Hand.* An accurate dissection of the fascia of the hand is considered the most important procedure in attempting to arrive at an understanding of the so-called fascial spaces. Fascial and aponeurotic strata of the hand, especially in their formation of important surgical spaces, have been in-

adequately or improperly described in textbooks or anatomical literature. I believe that some understanding of the entire fascial distribution of the hand will clarify our knowledge of the surgically important fascial spaces of the hand. The hands were obtained from the autopsy room, cadavers, and some specimens were obtained following surgical removal of the upper extremity.

3. *Injection of Radiopaque Material.* A mixture of two parts petrolatum, one part cotton seed oil, and one part bismuth subnitrate was injected into the deep fascial spaces by the open method, through the superior boundaries of the fascial spaces, to show comparative relationship of pus accumulations to metacarpal bones. Solutions containing red lead and a 65 per cent solution of barium sulfate in a mixture of acacia may also be used.

CLINICAL OBSERVATIONS

Material and Incidence. One hundred cases of deep fascial space infections of the hand were studied at the Boston City Hospital. These were the most recent cases encountered at the hospital.

Location	Cases	Right Hand	Left Hand
Thenar	70	43	27
Midpalmar	30	22	8

In this series the thenar space infections were found more than twice as frequently as midpalmar space infections. The right hand was involved more often with each infection, almost twice as often as the left, with thenar space abscess, and more than twice as often with midpalmar space abscesses.

Mortality. There was a 3 per cent mortality rate in this series. The causes of death were bronchopneumonia, septicemia and uncontrolled diabetes.

Localization. In this series there was a tendency for infection to remain localized in one space. In no case was a direct exten-

ETIOLOGY: THENAR SPACE ABSCESS
(70 cases)

Type of Cases	Instruments or Focus of Infection
27 puncture wounds...	8 wooden splinters, 5 needles, 3 broken glass, 1 pointed broom handle, 1 lead pencil, one nail, 1 tin can, 1 key ring, 1 pointed scissors, 1 wire
13 tenosynovitis......	8 index fingers, 3 thumbs, 2 midfingers
7 septic abrasions....	Over the thenar space, on palm
6 septic blebs........	Over the thenar space, on palm
4 cellulitis...........	2 over the thenar space, on palm, 2 from thumb
3 abscesses.........	2 subcuticular, palmar, one metastatic (bacteremia)
3 burns of palm......	2 curling iron, 1 carton of matches
3 osteomyelitis......	2 involved second metacarpophalangeal joint (human bites), 1 involved second and third metacarpal bones
2 septic lacerations...	Over thenar space, on palm
1 septic callus.......	Over thenar space, on palm
1 lumbrical space....	Index finger

MIDPALMAR SPACE ABSCESS
(30 cases)

Type of Cases	Instruments or Focus of Infection
8 lumbrical space abscesses.	8 involved lumbrical canal of ring finger
6 puncture wounds....	3 wooden splinters, 1 tack, 1 pin, 1 steel wool
4 septic abrasions.....	Over midpalmar space, on palm
3 tenosynovitis.......	2 midfingers, 1 ring finger
3 septic blebs.........	Over midpalmar space, on palm
3 cellulitis...........	Over midpalmar space
2 osteomyelitis.......	1, the fourth metacarpophalangeal joint (human bite), 1, the third metacarpal (dorsal space abscess)
1 septic laceration....	Involved web between third and fourth right fingers

sion to forearm found. In two of the one hundred cases, both spaces became eventually involved. In each of the two cases the midpalmar space infection was secondary to the thenar space infection and was the result of extensive necrosis.

Differential Diagnosis. Tenderness over the palmar aspect of the space involved is probably the most important sign. Swelling is of value. With midpalmar space abscess there is obliteration of the concavity of the palm and a slight bulge over the palm. With thenar space abscess there is usually a rapid increase in size of the thenar area. The tissues of the thenar area seem to

balloon out from the radial longitudinal crease of the palm. There is usually great swelling over the dorsum of hand with both infections. Position of the fingers is of some value. The middle and ring fingers are flexed when the midpalmar space is involved. The index finger is usually flexed when the thenar space is involved. Temperature ranges from 100 to 104°F. with each infection.

Treatment. The thenar space is best drained by transverse incision over the dorsum of the thumb-index web, at the middle of a line drawn between the distal ends of the metacarpal bones of the thumb and index fingers with the thumb in a position of abduction. Two incisions have been used for midpalmar space abscesses. Preferably a transverse incision is made over the distal transverse crease or an incision parallel to this crease directly over the center of the palmar convexity. Digital blood vessels and nerves must be identified. The vertical incision in the web between ring and little fingers, or in the web between mid and ring fingers may be used when large abscesses are found in the third and fourth lumbrical spaces. However, this incision has been followed by contractures when unwisely placed, when carried too far proximally, or at times when the web is completely severed.

Clinical Deductions. Deep fascial space abscesses of the hand tend to remain localized. Rarely, a spread from one space to another is found when local barriers are destroyed by necrosis.

ANATOMICAL DISSECTION OF FASCIA OF THE HAND

One hundred hands were dissected. The drawings are accurate portrayals of anatomical details in one dissection, and not a composite based upon several different dissections. Photographs were taken to reproduce important details.

Skin and Superficial Fascia. Two incisions were made in the skin of the palm, one longitudinally and one transversely through the center of the palm. Each of

four flaps was dissected free. Beneath the skin of the palm there is a layer of fatty tissue. From the palmar aponeurosis septa

divides into two processes which are inserted into the fibrous sheaths of the flexor tendons. From the sides of these processes
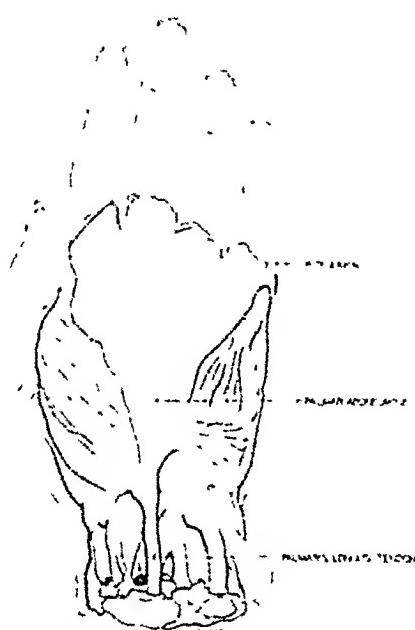
FIG. 1. Drawing of palmar aponeurosis.

FIG. 2. Drawing of septa from palmar aponeurosis forming compartments for flexor tendons and lumbrical muscles.

pass to the skin. These septa are vertical except in the region of the proximal and distal transverse creases of the palm where the septa are transverse or oblique. These septa constitute the superficial palmar fascia. Their presence accounts for the lack of mobility of the palmar skin.

Palmar Aponeurosis. The palmar aponeurosis invests the muscles and tendons of the palm. It consists of central, lateral and medial portions. (Fig. 1.) The central portion occupies the middle of the palm, is triangular in shape and of great strength and thickness. Its apex, deeply, is continuous with the distal margin of the transverse carpal ligament, and more superficially, receives the expanded tendon of the palmaris longus. Its base divides distally into four slips, one for each finger. Each slip gives off superficial fibers to the skin of the palm, and finger, those to the palm joining the skin at the furrow corresponding to the metacarpophalangeal articulations, and those to the fingers passing into the skin at the transverse fold at the bases of the fingers. The deep part of each slip sub-

offsets are attached to the transverse metacarpal ligament. At the points of division into slips, numerous strong fasciculi bind the separate processes together beneath the webs of the fingers. From the undersurface of the distal one-third of the palmar aponeurosis, septa are given off to fascia of interossei which separate the flexor tendons from the lumbrical muscles. The palmar aponeurosis gives off a septum on either side, which is continuous with the interosseous fascia, and separates the intermediate from the collateral group of muscles.

The lateral and medial portions of the palmar aponeurosis are thin fibrous layers which cover on the radial side the muscles of the little finger. They are continuous with the central portion, and with the fascia on the dorsum of the hand. The palmar aponeurosis may be considered as part of the fibrous investment of the entire hand, which in the midpalmar area is quite complicated. Superficial septa from the

superficial surface attach the palmar aponeurosis firmly to the superjacent skin. Septa arising from the deep aspect of the palmar aponeurosis serve to attach the aponeurosis firmly to the subjacent interosseous and adductor fascia. These septa divide the distal part of the midpalmar space into smaller compartments. The palmar aponeurosis beyond the hypothenar and thenar eminences is continuous with the fascia on the dorsum of the hand. Beneath the palmar aponeurosis is a thinner layer of fascia, which follows the internal aspect of the palmar aponeurosis but is not firmly attached to the heavier superjacent aponeurosis.

The Subaponeurotic Fascia. The subaponeurotic fascia is the thin fibrous tissue which lines the inner aspect of the palmar aponeurosis. It is this fascia which seems to be the source of the most confusion in investigations of the fascia of the hand. The palmar aponeurosis was cut from its origin with the palmaris longus tendon and transverse carpal ligament. The medial and lateral attachments were cut in the region of the hypothenar and thenar eminences. The palmar aponeurosis was then reflected and the longitudinal septa from the undersurface of the distal one-third of the palmar aponeurosis were incised. These septa divide the palmar cavity distally into channels for the flexor tendons and lumbrical muscles. (Fig. 2.)

The thin fascia lines the inner surface of the palmar aponeurosis throughout its course, and is distinct over the floor of the cavity as well as beneath the central portion of the palmar aponeurosis. Anteriorly or superficially, the thin fascia winds between and around the flexor tendons and holds them in a semifixed position. Laterally and medially, thin fascia is found internal to the projections of the palmar aponeurosis. The strong fibrous septa from the inner surface of the distal one-third of the palmar aponeurosis received an investment from the thin fascia as they form channels for the lumbrical muscles and flexor tendons. The floor of the midpalmar

cavity is covered by thin fascia as it becomes the fascia for the interossei. As the thin fascia surrounds the flexor tendons, a

Fig. 3. The middle palmar septum coming from undersurface of flexor digitorum profundus of the midfinger to third metacarpal bone dividing palm into midpalmar and thenar spaces.

definite septum comes from beneath the flexor digitorum profundus tendon of the midfinger and is attached to the third metacarpal bone.

The Middle Palmar Septum. In all of the one hundred cases examined, a definite septum of thin fascia was found beneath the flexor digitorum profundus tendon of the midfinger. The septum arose from the thin fascia which interwound and surrounded the flexor tendons, and was attached to the periosteum of the third metacarpal bone throughout its entire length. This important surgical septum divides the palmar cavity into the midpalmar and thenar spaces. In all specimens examined, the septum extended proximally at least as far as the distal edge of the

transverse carpal ligament. In twenty-five of the one hundred cases, the septum extended one inch proximal to the distal

lateral fascial arm then continues over the lateral edge of the adductor muscle and is attached to the posterior aspect of the
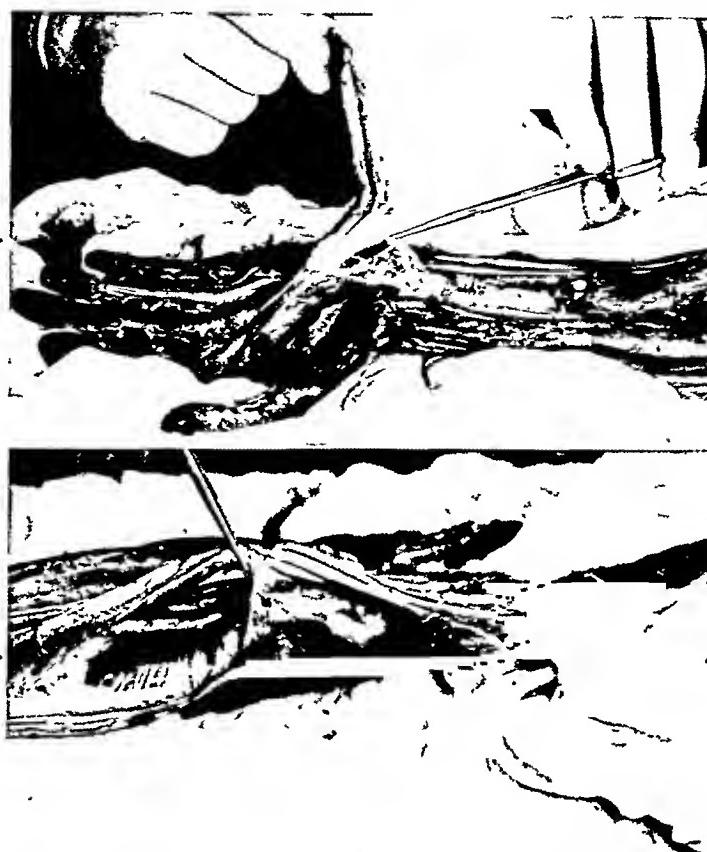
Fig. 4. The middle palmar septum as it forms lateral boundary of the midpalmar space.

Fig. 5. The middle palmar septum as it forms medial boundary and roof of the thenar space.

edge of the transverse carpal ligament. (Fig. 3.)

The middle palmar septum has a definite structure. As this septum leaves its attachment to the middle metacarpal bone it is one membrane. The distal one-half of the septum, usually about one-half way between attachments to flexor tendons and middle metacarpal bone, splits in a Y-shaped fashion. The medial arm of the "Y" continues toward the flexor tendons and ends beneath the third flexor tendons to complete the lateral boundary of the mid palmar space. (Fig. 4.) The lateral arm of the "Y" curves laterally, surrounds the flexor tendons of the index finger and then continues laterally, covering very loosely the adductor pollicis muscle. This thin

adductor pollicis muscle about one-half way down the dorsum of the muscle. This lateral thin fascial arm may be called the fascia for the adductor muscle and forms the medial boundary and roof of the thenar space. (Fig. 5.) Proximally, the thenar space is bounded by a fold of the thin fascia which covers the adductor pollicis muscle. In none of the one hundred cases was there any communication between the midpalmar and thenar spaces. In no case could an instrument be carried across the palm beneath the flexor tendons without meeting obstruction by the middle palmar septum. (Fig. 6.)

Other Palmar Septa. Strong fibrous septa arise from the undersurface of the palmar aponeurosis and receive an invest-

ment from the subjacent, thin fibrous layer. These become attached to fascia covering the interosseous muscles and so form chan-

the dorsum of the hand, splits, ensheaths the extensor tendons and fuses between the extensor tendons.
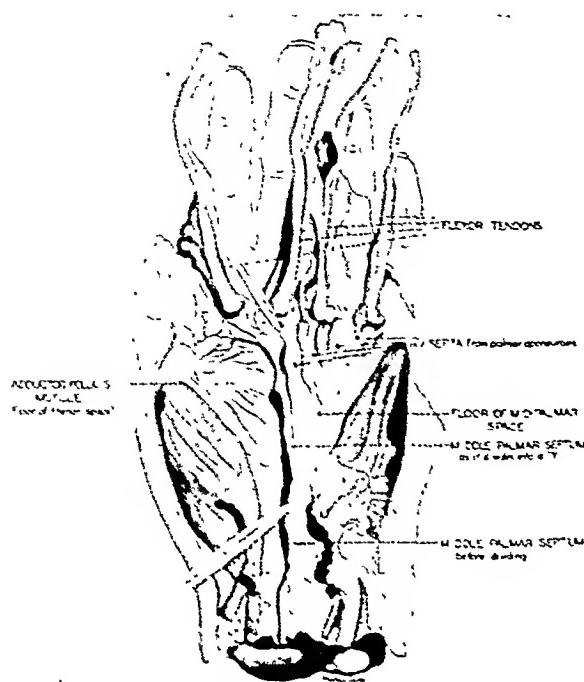
FIG. 6. Drawing of floor of midpalmar and thenar spaces. Septa are seen in distal one-half of midpalmar space. The middle palmar septum is seen as it divides in a Y-shaped fashion.

nels for the lumbrical muscles and flexor tendons. These septa extend no further proximal than the distal transverse palmar crease.

Fascia on Floor of Palmar Space. From the posterior aspect of the fascia of the interossei, septa are given off deeply which are attached to the metacarpal bones. The medial septum surrounds the third volar interosseous muscle and then becomes attached to the fifth metacarpal bone. The middle septum surrounds the second volar interosseous muscle and is attached to the fourth metacarpal bone. The lateral septum surrounds the first volar interosseous muscle and becomes attached to the second metacarpal bone. (Fig. 7.) The dorsal interosseous muscles are covered by fascia to form separate fascial compartments.

Dorsal Fascia. The palmar aponeurosis continues around the muscles of the thenar and hypothenar eminences and a slip is given off to the first and fifth metacarpal bones. The aponeurosis then continues over

FIG. 7. Diagrams of fascial distribution found in cross sections through proximal one-third and distal one-third of the palm.

INJECTION OF RADIOPAQUE MATERIAL

A mixture of two parts petrolatum, one part cotton seed oil, and one part bismuth subnitrate was injected into the deep fascial spaces by the open method through the proximal boundaries of the fascial spaces. Roentgenograms were made to show a comparative relationship of pus accumulations to metacarpal bones. (Fig. 8.)

CONCLUSIONS

Anatomical dissection of the fascia of one hundred hands reveals that there is a definite midpalmar and thenar space. Infections of deep fascial spaces of the hand substantiated the concept of these spaces.

The midpalmar space extends from the middle metacarpal bone ulnarward to the radial side of the metacarpal bone of the little finger. Anteriorly, this space is bounded by the flexor tendons of the middle, ring and little fingers, the third and fourth lumbrical muscles and the thin fascia which connects these tendons and muscles. The posterior boundary or floor is formed by

the fascia, covering the second and third volar interosseous muscles, and the third, fourth and fifth metacarpal bones. In the

The thenar space is bounded posteriorly by the adductor pollicis muscle. Medially, the boundary is the middle palmar septum,

FIG. 8. X-rays of the midpalmar and thenar spaces filled with radiopaque material.

distal one-third of the floor, small compartments are formed, as septa coming from the undersurface of the palmar aponeurosis are attached to the fascia of the volar interosseous muscles. These small compartments communicate with the midpalmar space. The medial boundary is the fascia on the radial side of the hypothenar muscles. The lateral boundary is the middle palmar septum which extends from the undersurface of the flexor digitorum profundus tendon of the midfinger to the middle metacarpal bone.

Distally, the midpalmar space extends to about 2 cm. proximally to the webs. The distal boundary is composed mainly of the fascial septa extending from the palmar aponeurosis to the floor of the space and some transverse fasciculi. The proximal boundary is a thin fascial septum usually found at about the level of the proximal end of the transverse carpal ligament. However, clinically, abscesses do not usually tend to enter the carpal tunnel. This fact is probably due to tissue response to infection, i.e., serous, cellular and fibrinous reactions.

a thin fascia extending from beneath the flexor digitorum profundus tendon of the midfinger to the third metacarpal bone. Proximally, in all cases, thin fascia, which is a part of the adductor fascia, forms the boundary. This proximal boundary is found at about the level of the distal end of the transverse carpal ligament. The anterior boundary or roof is the thin layer of fascia, formed as the middle palmar septum splits and courses laterally. In its lateral course this thin fascia roof ensheaths the flexor tendons of the index finger to form part of the anterior boundary. The lateral boundary of the thenar space is formed by the thin fascia as it extends over the lateral edge of the adductor pollicis muscle and is attached to the dorsal aspect of this muscle. This distribution of fascia over the anterior, lateral and dorsal aspects of the adductor pollicis muscle clearly indicates why abscesses of the thenar space may extend to the posterior aspect of the muscle. However, the fact remains that abscesses of the thenar space tend to remain anterior to the adductor pollicis muscle.

REFERENCES

1. BRICKEL, A. C. J. Surgical Treatment of Hand and Forearm Infections. St. Louis, The C. V. Mosby Co.
2. KANAVEL, A. B. Infections of the Hand. Philadelphia, Lea and Febiger.
3. GRAY, H. Anatomy of the Human Body. Philadelphia, Lea and Febiger.
4. COLLANDER, C. L. Surgical Anatomy. Philadelphia, W. B. Saunders.
5. KOCH, S. L. Prevention and treatment of infections of the hand. *J. A. M. A.*, pp. 1365–1367, March 29, 1941.
6. MASON, M. L. and ALLEN, H. S. Indelible pencil injuries. *Ann. Surg.*, 113: 131–139, 1941.
7. BELLONE, A. Osteoaponeurotic cavities of the palm, roentgen study to determine mode of propagation of suppurative processes. *Arch. di radiol.*, 15: 491–495, 1939.
8. ANSON, B. J. and ASHLEY, F. L. Midpalmar compartment, associated spaces and limiting layers. *Anat. Rec.*, 78: 389–407, 1940.
9. PEMBERTON, P. A. Infection of fascial spaces of palm. *Am. J. Surg.*, 50: 512–515, 1940.
10. SPAULDING, J. E. Fascial spaces of palm; surgical anatomy. *Guys Hosp. Rep.*, 88: 432–439, 1938.
11. WILKIE, D. Septic hand. *Brit. M. J.*, 2: 1127–1130, 1938.
12. RUSSELL, E. P. Deep infections of hand. *J. Iowa M. Soc.*, 26: 689, 1936.
13. TOLDT, C. Human Anatomy. New York City, Rebman Co.
14. VON STAPELMAHR, S. Cavities of the hand from a surgical point of view. *Nord. med. tidskr.*, 10: 1341–1344, 1935.
15. FLACK, F. L. Fascial space and bursal infections. *J. Oklahoma M. A.*, 27: 314–318, 1934.
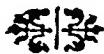
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ULTRAVIOLET IRRADIATION OF AUTOTRANSFUSED BLOOD IN THE TREATMENT OF POSTABORTIONAL SEPSIS

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FROM July, 1938, through July, 1941, in the Shadyside Hospital, Pittsburgh, Pennsylvania, ultraviolet irradiation of autotransfused blood has been used as an adjunct to surgery in the treatment of postabortional sepsis. Seventeen patients were treated preoperatively and four postoperatively. Nine patients admitted instrumentation to produce abortion; two patients admitted taking medication. Eight abortions were apparently spontaneous. One patient with psychosis was treated after a therapeutic abortion because of apparent sepsis. One patient used medication and instrumentation. Ten patients were considered in a state of advanced infection on admission. Eleven were considered as early to moderately advanced infections, based on symptoms of fever, increased leukocyte counts, history of criminal abortions, toxemia, etc. The pathological conditions ranged from simple, uncomplicated, acute septic endometritis to acute salpingitis, bilateral, "frozen" pelvis, pelvic abscess and septicemia. Chemotherapy (sulfanilamide) was used in treating two patients; one patient receiving 530 gr. in five days; another (Case III) 135 gr. in thirty-six hours. In the first case it apparently was not helping the patient; and in the second case it was cancelled after irradiation as not needed.

One patient (Case X) was admitted with escherichia coli septicemia, the same organism being obtained from her uterus at operation. Three patients showed transient bacteriemia at operation. The patient in Case V at operation showed indifferent streptococci in the blood and uterus. The patient (Case XI) showed indifferent strep-

tococci in the blood and Staphylococcus aureus in the uterus at operation. The patient (Case XII) showed pneumococci in the blood and uterus at operation, the organism was not specific in type. (It has been our experience in other pneumococcal infections that hemo-irradiation tends to act on the pneumococcus in some manner, making it unsuitable for typing.)

Cultures from the cervical canal, uterine cavity and including one cul-de-sac abscess showed:

Escherichia coli	3
Hemolytic streptococcus	2
Indifferent streptococcus	1
Staphylococcus	4
Diphtheroids	1
Pneumococcus	1
No growth	4
No cultures taken	7

(Two patients were readmitted.)

Whenever possible, our practice was to give preoperative blood irradiation and either immediately or the following day perform dilatation and curettage. In no case did we observe any spread of infection. When this therapy was used postoperatively in four patients with advanced infection, prompt relief of toxemia and decrease in fever was outstanding.

Blood irradiation therapy was given as follows:

19 days preoperatively	1
4 days preoperatively	2
1 day preoperatively	11
immediately before operation	4
2 days postoperatively	1
3 days postoperatively	2
4 days postoperatively	1

(One patient was readmitted.)

The four patients not treated preoperatively showed symptoms of temperature

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rise and toxemia following surgery and were treated postoperatively because of apparent acute endometritis. It is noteworthy that no significant rises of temperature were observed even though the patients were treated at different intervals preoperatively. The results were essentially the same and strongly indicate the preventative value of hemo-irradiation.

CLINICAL OBSERVATIONS AND RATIONALE

This therapy consists in the administration of ultraviolet irradiation directly to the blood. By this method of application many of the important biophysical and biochemical effects produced by ultraviolet rays can be observed clinically. The reactions of special interest in this condition under discussion, which have a broad background in general medical literature, and which can be observed clinically are:

1. Attenuation and destruction of bacteria.[3,5,6,16]

2. Inactivation of toxins and viruses.[9,11,15]

3. Increased absorption of oxygen by the blood.[8,10,12]

4. Increase in general resistance to infection.[4]

The work of the author in puerperal sepsis[14] and the papers by Hancock and Knott,[7] Barrett,[1,2] and Miley,[12,13] reporting the use of this method all emphasize these manifestations following such treatment. The results observed in patients following such treatment substantiates clinically that these and other reactions characteristic of ultraviolet spectral energy take place in hemo-irradiation.

The increase in general resistance following ultraviolet therapy has been thoroughly reviewed by Clark,[4] and is observed following hemo-irradiation. A significant fact is brought to notice in this series of cases in reviewing the charts and histories. None of the seventeen patients treated preoperatively had any untoward symptoms, following dilatation and curettage, as would be expected.

TECHNIC

The observable phenomena of systemic reaction to this form of treatment are consistent in a majority of cases. This is probably due to the fact that in the application of ultraviolet directly to the blood, using the Knott technic, a constant and exact control of all the variable dosage factors is maintained. Intensity of ultraviolet radiation, wave length, distance, time of exposure and volume of blood treated are all important factors that are controlled by this method.

The method of exposing venous blood directly to ultraviolet spectral energy and returning to the patient was evolved by E. K. Knott, of Seattle, Washington. This procedure became known as the "Knott Technic," and it was this method that Hancock and Knott, Barrett, Rebbeck, and Miley employed in the work they have reported.

The Knott technic consists in the withdrawing of a predetermined amount of blood from a patient and the exposure of this blood after citration to a selected band of wave lengths of ultraviolet rays and immediately returning it to the patient. This technic has been described in detail by Miley. It is essentially a surgical procedure. However, an apparatus has been designed that mechanically regulates all factors and through precise but simple operation makes the administration of this therapy a safe procedure.

Case I. No. 75795. Mrs. K., age thirty-one, married, was admitted to the Shadyside Hospital November 2, 1938. She gave a history of her last menstrual period beginning October 18, and continuing until admission accompanied by moderately severe crampy pains in the lower portion of her abdomen. She denied any pregnancy or attempt at abortion. Her admission temperature was 102.2°F., pulse 120, respirations 24. An admission blood count was not done. Pelvic examination showed a large, tender, boggy mass posterior to the uterus with the cervix patent, uterus slightly enlarged and fixed anteriorly, adnexa not definable. She received

blood irradiation therapy preoperatively on the third admission day. A routine curettement plus incision and drainage of the cul-de-sac

FIG. 1. Case 1.

abscess was performed on the fourth day. As shown by the accompanying graph the temperature gradually receded. The patient made an uncomplicated recovery and was discharged in good condition on the eighth postoperative day. Examination of curettings showed acute endometritis with necrotizing placental tissue. Culture from the abscess

spontaneous abortion occurred, but the bleeding continued although slight in amount. About two hours prior to admission she developed severe crampy pains in the lower portion of her abdomen and severe vaginal bleeding. Her admission temperature was 98.6°F. pulse 104, and respirations 22; blood count was 3,030,000 red cells with 6 Gm. hemoglobin. A curettage was performed shortly after admission, and the products of conception, consisting of necrotizing placental tissue,
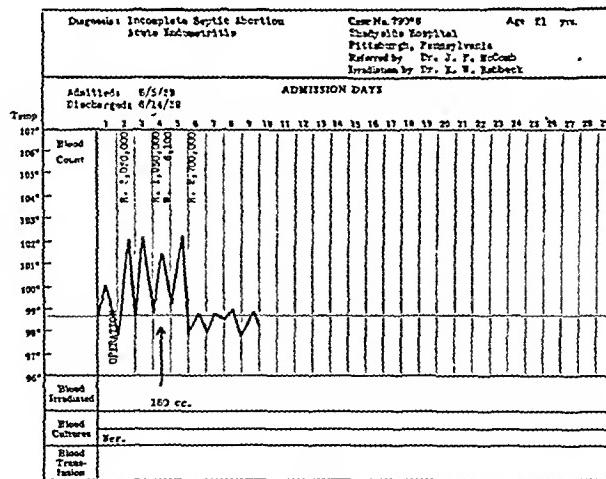
FIG. 2. Case II.

showed staphylococcus. We believe this patient perforated the uterus in an attempt at abortion in spite of her denials.

CASE II. No. 79088. Mrs. M., age twenty-one, was admitted June 5, 1939, with a history of bleeding for approximately three weeks. She was estimated two months pregnant at the time bleeding began. One week later a

removed. No uterine culture was taken. There was considerable bleeding at operation, and a count taken June 8, 1939, showed red cells 1,950,000, 5.8 Gm. hemoglobin, 6,100 white cells with 86 per cent neutrophiles (78 nonfilamented). At this stage her temperature showed a decided tendency to a septic course. She was moderately toxic and quite weak.

Blood irradiation therapy was instituted on June 8. This was followed by a transient rise the next day then prompt recession to normal.

degrees. By the morning of May 31, despite her temperature being normal, she was still moderately toxic. Blood count on May 31,
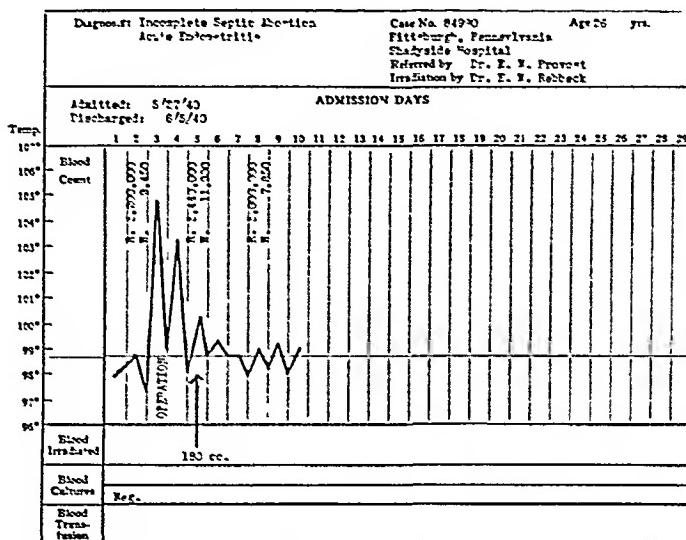
Fig. 3. Case III.

The patient felt decidedly better from the time she was irradiated. No bacterial growths were obtained from the blood. This fever was evidently sapremic in nature; however, the decided tendency to sepsis caused considerable concern. The patient was discharged on the ninth postoperative day in good condition. Her subsequent recovery was uneventful.

CASE III. No. 84990. Mrs. O., age twenty-six, para III, was admitted to the Shadyside Hospital on May 27, 1940, with a history of having fallen down steps at approximately the third month in her pregnancy and a spontaneous abortion ensued. This occurred six weeks prior to admission. She had slight to moderate amount of bleeding daily since the abortion occurred. She denied any attempt at self-induced abortion. Her admission temperature was 97.8°F. pulse 112, respirations 20. The day following admission her blood count showed red cells 3,200,000, hemoglobin 12.5 Gm., color index 1.2, leukocytes 9,450, neutrophiles 69 per cent (filament 29, nonfilament 40). A dilatation and curettage was performed on May 29. The pathological report showed necrotizing placental tissue. Approximately two hours after this surgical procedure she had a chill and her temperature rose to 104.8°F. with pulse 136, respirations 24. Sulfanilamide was immediately started, 140 gr. being given in the next thirty-six hours. During this time she had two more chills, her temperature ranging up to a peak of 103

showed 3,440,000 red cells, 10.2 Gm. hemoglobin, color index 1, leukocytes 11,900, neutrophiles 83 per cent (filament 31, nonfilament 52), sedimentation distance 79 mm. in one hour. Chiefly because of the moderate toxemia and septic blood count sulfanilamide therapy was discontinued on May 31, in favor of blood irradiation therapy, which was given the same day. Blood cultures taken May 30 and 31 were negative. No cultures were taken from the cervix or uterus. On June 1, the patient was markedly improved in all respects and continued to an uneventful recovery and discharge on June 5, 1940.

CASE IV. No. 88227. Mrs. C., age twenty-eight, married, was admitted to the Shadyside Hospital November 16, 1940. She had missed two menstrual periods and three weeks prior to admission began to have vaginal bleeding with moderate cramps. During this period she had two rather severe hemorrhages. The night prior to admission a severe hemorrhage with cramps occurred. The patient finally admitted that she had used a slippery elm stick six different times during these three weeks (she had inserted a slippery elm stick into her uterus six different times prior to admission). Her admission temperature was 99.2°F., pulse 100, respirations 20. Blood count showed 3,170,000 red cells, 10 Gm. hemoglobin, 3,350 leukocytes, 73 per cent neutrophiles (12 nonfilament, 61 filament). Urine showed considerable albumin, occa-

sional pus and blood. Culture from the cervix showed Staphylococcus aureus and hemolytic streptococcus. Blood culture November 22,

FIG. 4. Case IV.

showed no growth. Gynecological examination revealed an enlarged, softened cervix, bleeding with uterus enlarged to correspond to two months' pregnancy. The right tube and ovary were enlarged and tender. On November 18, the patient received routine curettement for incomplete abortion. At this time not much tissue was recovered, and the curettings sent

shown by the accompanying graph temperature promptly receded, and the patient was discharged on the seventh postoperative day in good condition. Her subsequent progress has been uneventful. The right tubo-ovarian infection has not become exacerbated.

CASE V. No. 88526. Mrs. G., age twenty-one, married, was admitted to the Shadyside Hospital on December 2, 1940, with a history of a self-induced abortion performed two days prior to admission, at which time her period
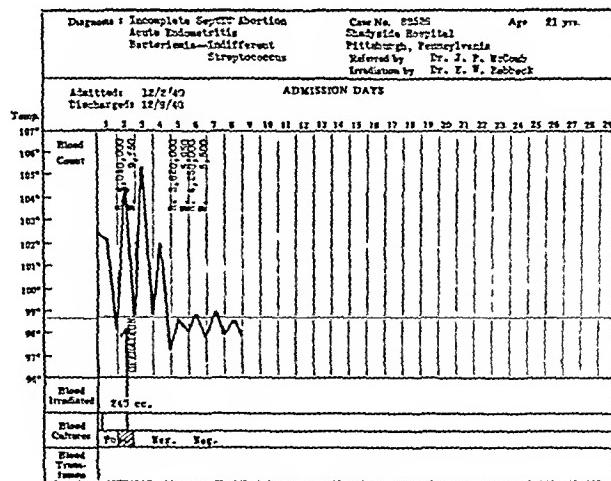
FIG. 5. Case V.

to the laboratory showed nothing but proliferating endometrium with marked congestion and inflammatory reaction. Diagnosis of pregnancy was not proved by laboratory. By the third postoperative day with chills temperature had reached 103.4°F. She was moderately toxic. On the fourth postoperative day blood irradiation therapy was instituted and as

was approximately two weeks late. She used a catheter for the abortion. Her admission temperature was 102.2°F., pulse 100, respirations 22. She had rather frequent chills, the longest lasting twenty minutes and by the evening of December 3, her temperature reached a peak of 104.6°F., pulse 120. Blood irradiation therapy was instituted on Decem-

ber 3, and a dilatation and curettage performed on December 4. The pathological report showed early placental tissue with

FIG. 6. Case VI.

inflammatory reaction. Blood culture taken at the time of the curettement showed indifferent streptococci. Subsequent blood cultures taken December 4 and 5 were negative. A smear from the cervix taken at the time of curettement showed indifferent streptococci. Her temperature reached a peak of 105.2°F. the evening following curettement but, as shown by the accompanying graph, promptly subsided; and the patient was discharged in good condition on December 9, 1940. Her subsequent recovery has been uneventful.

CASE VI. No. 88580. Mrs. M., age twenty-three, married, was admitted to the Shadyside Hospital December 5, 1940. She gave a history of having missed two menstrual periods. She inserted a catheter into the uterus on November 29. This was followed three days later by chills, severe cramps in the lower abdomen and passage of blood with clots but no fetus. Her admission temperature was 101.2°F., pulse 112, respirations 18. Blood count showed 4,850,000 red cells, 15.4 Gm. hemoglobin, 9,000 leukocytes, 76 per cent neutrophiles (13 filament, 63 nonfilament). Gynecological examination showed blood clots in the vagina; enlarged, softened, patent cervix; bleeding; uterus enlarged to correspond to approximately two months' pregnancy, slightly tender, no adnexal masses or unusual tenderness. Blood cultures taken December 6 and December 7 were negative.

She received blood irradiation therapy on the second admission day, and routine curette-

ment was performed on the third day. No uterine culture was taken. The curettings showed necrotizing placental tissue. As shown by the accompanying graph she made an uneventful recovery and was discharged in good condition on the fourth postoperative day. Her subsequent convalescence has been uneventful.

CASE VII. No. 89678. Mrs. B., age forty, married, was admitted to the Shadyside Hospital on February 4, 1941. She gave a history of missing two menstrual periods prior to January 25, then began to bleed. The bleeding with clots has persisted since. She has six children living and well with a miscarriage four years ago. She denied any attempt at interruption of her pregnancy. Stated that she had had a "cold" for the past two weeks. Her admission temperature was 102.6°F., pulse 128, respirations 24. Blood count showed: red cells 3,410,000; hemoglobin 9 Gm.; leukocytes 11,350; neutrophiles 84 per cent (filament 30, nonfilament 54). A gynecological examination revealed the vagina filled with clots; softened, enlarged, patent cervix with bleeding; uterus enlarged to correspond to ten weeks' pregnancy, slightly tender, no adnexal masses. She received blood irradiation therapy on the second day. The following twenty-four hours her temperature reached a peak of 100.6°F. She received routine curettement on the third day. The pathological report showed necrotizing placental tissue. As shown by the accompanying graph, the patient made a rapid recovery to be discharged on the fifth postoperative day. Her subsequent convalescence was uneventful

CASE VIII. No. 92416. Mrs. R., age thirty-one, married, was admitted to the Shadyside Hospital June 23, 1941. Her last menstrual

FIG. 7. Case VII.

period was due approximately June 14. On June 16, she was given quinine tablets "by some woman" who, likewise, inserted something into her uterus. Aside from an occasional crampy pain nothing happened until June 19, when she began to bleed moderately. The cramps became more severe and she felt warm. No tissue, however, was passed. These

in severity. When she finally called a physician her temperature had reached 104 degrees on the morning of June 23. She was immediately sent to the hospital. Her admission temperature was 101.4°F., pulse 128, respirations 28. Blood count showed: 3,400,000 red cells, 11.8 Gm. hemoglobin, 14,400 leukocytes, 85 per cent neutrophiles, 21 per cent filament, 64 per cent nonfilament. Pelvic examination revealed a softened cervix with profuse sanguinopurulent, nonoffensive discharge from
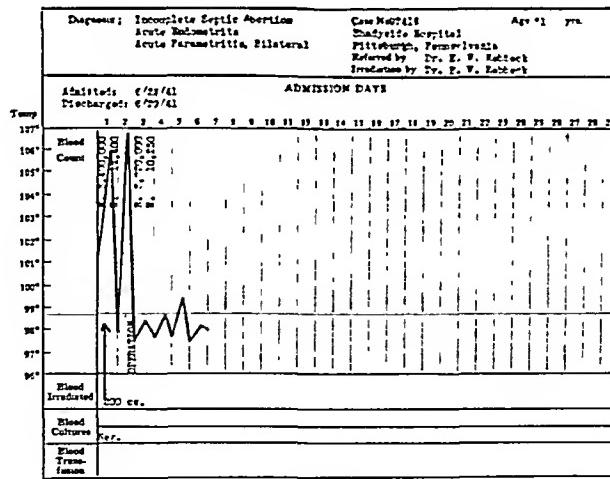
FIG. 8. Case VIII.

symptoms continued until June 21, when she began to have chills and felt considerably warmer. Headache developed and nausea and vomiting. Over the next forty-eight-hour period these symptoms became considerably aggravated with much more severe pain across the lower part of the abdomen, constant and also colicky in nature. The chills increased

the cervical canal, filling the vagina. The uterus was enlarged to correspond to six weeks' pregnancy, moderately tender, both lateral regions tender, especially right, no masses. Hot gallon douches of bichloride 1:5000 were given four hourly (we believe for this reason when operation was done, no growth was obtained).

Blood irradiation therapy was instituted about six hours after admission, and the following day routine curettement was performed.

acetone. Her temperature receded by the next day considerably and she felt much improved. On July 2, the second admission day, blood
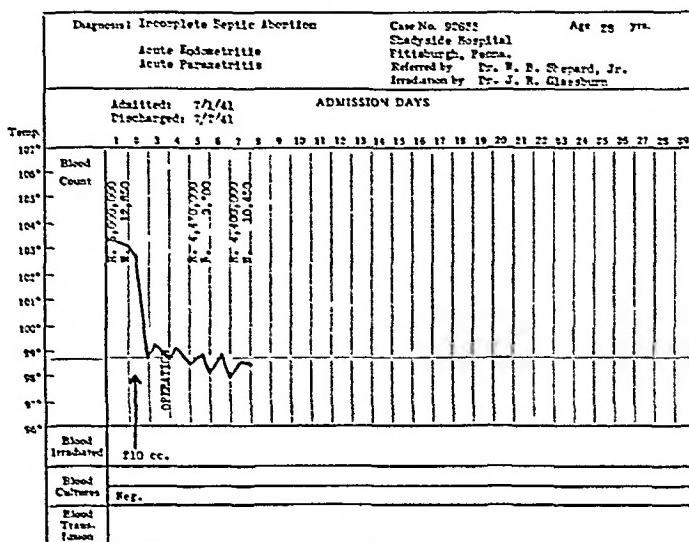
Fig. 9. Case ix.

At operation a small fetus with membrane and decidua was removed. Culture taken from the cervix showed no growth. As shown by the accompanying graph the patient made a prompt recovery, was discharged in good condition on the fifth postoperative day. Examination of the pelvis by her family physician one month later failed to reveal any evidence of pelvic infection.

CASE IX. No. 92633. Mrs. B., age twenty-eight, para 11, was admitted to the Shadyside Hospital July 1, 1941. She gave a history of having had an abortion about four weeks previous, etiology unknown, denied any attempt at interruption, and was apparently about six weeks pregnant at the time. After the abortion she was apparently in good condition until the night of June 30, when she experienced sudden sharp, burning pain over the entire lower part of her abdomen with vomiting. The pain persisted continuously and severe, and was aggravated by urination. On admission an enlarged, softened uterus, quite tender, immobile, was found with bloody serous discharge from the cervical canal. The diagnosis of "frozen pelvis" was made preoperatively. Her admission blood count was 5,000,000 red cells, 86 per cent hemoglobin, 12,850 leukocytes, 83 per cent neutrophiles (66 filament, 17 nonfilament), sedimentation distance 6 mm. in one hour. Her temperature on admission was 103.2°F., pulse 112, respirations 32. Urine showed a moderate number of leukocytes, many erythrocytes and a trace of

irradiation therapy was instituted. A culture taken before irradiation showed no growth. Routine curettement was performed on July 3. A moderate amount of purulent endometrial tissue was removed. A pathological examination of the tissue showed endometrium of pregnancy. The culture from the uterus showed diphtheroids. Blood culture taken July 3, was negative. As shown by the accompanying graph the patient made an uneventful recovery and was discharged on July 7, 1941 the fourth postoperative day, in good condition.

CASE X. No. 93021. Mrs. S., age twenty-nine, para 11, was admitted to the Shadyside Hospital July 18, 1941. Her last normal menstrual period occurred two months prior to admission; shortly after that she began to have considerable nausea and vomiting. She claims that she vomited after every meal. She also suffered from urinary frequency and marked constipation. She denied any attempt at self-abortion by instrumentation but admitted taking laxatives and quinine tablets beginning about one week prior to admission. About twenty-four hours prior to admission she began to have considerable pelvic crampy pains, increasing in severity, and a bloody vaginal discharge. Her admission blood count showed 3,530,000 red cells, 12.2 Gm. hemoglobin, 11,450 leukocytes, 84 per cent neutrophiles, (13 per cent filament, 71 per cent nonfilament), sedimentation distance 80 mm. in one hour. Vaginal examination revealed an enlarged, softened uterus, quite tender with

adnexal tenderness, a foul smelling and a profuse discharge from a softened cervix. Her admission temperature was 100.2°F., pulse

FIG. 10. Case x.

108, respirations 20, and in addition to severe crampy pains in the lower portion of her abdomen she complained of severe pain radiating from the right groin to the right lumbar region as if a pyelitis were developing. Her urine showed considerable albumin, many pus cells and erythrocytes with considerable mucus. She was given blood irradiation therapy in

ing placental tissue. A culture taken from the uterine cavity showed escherichia coli. As shown by the accompanying graph the patient's temperature promptly receded to normal. A blood culture taken July 22, showed no growth. She made an uneventful recovery and was discharged from the hospital symptom free on July 24, 1941.

CASE XI. No 93171. Mrs. G., a negro, age forty, para IV, was admitted to the Shadyside Hospital July 26, 1941. She gave
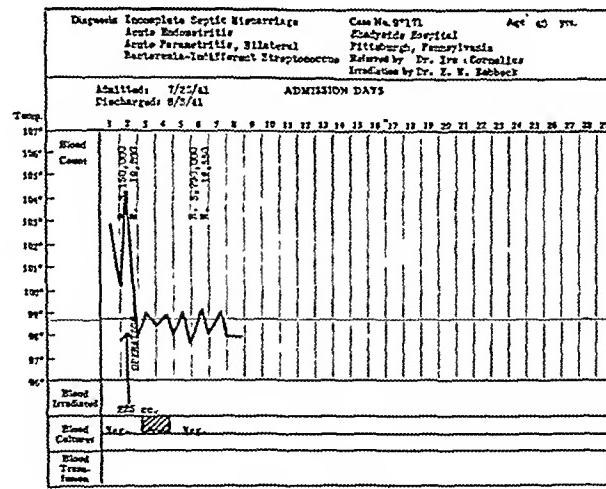
FIG. 11. Case XI.

the morning of July 19. A preoperative irradiation blood culture was taken which subsequently showed a profuse growth of escherichia coli. Routine curettement was performed on July 20. The peak temperature during this twenty-four hours being 101.4°F. At operation a considerable amount of foul smelling necrotizing placenta was removed from the uterine cavity. A pathological report showed necrotiz-

a history of having had a miscarriage at approximately four and one-half months; and on July 24, after some heavy lifting she experienced a sudden onset of crampy pain in her lower abdomen and profuse bleeding. A physician was called and shortly afterward a fetus and placenta were expelled. The bleeding decreased in amount. On the morning of admission she had recurrence of crampy

pains in the lower portion of her abdomen and rather profuse vaginal bleeding with many clots. She had several chills the twenty-four

being discharged on August 3, 1941, the seventh postoperative day, symptom free.

CASE XII. No. 93234. Mrs. O., age twenty,
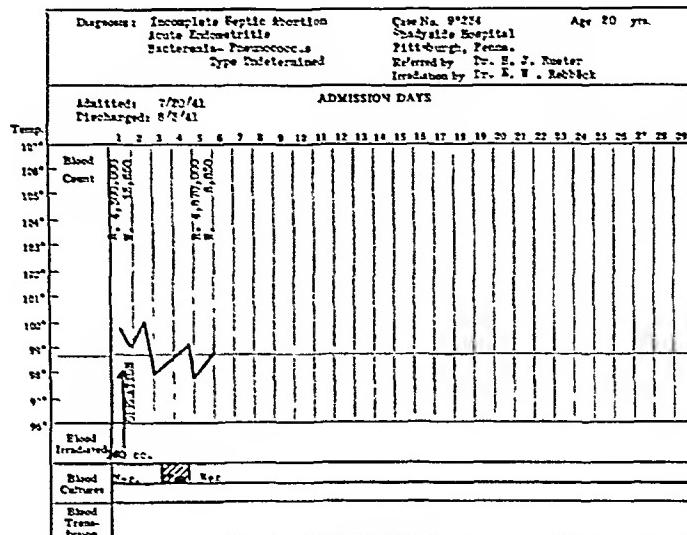
FIG. 12. Case XII.

hours prior to admission and had been suffering from considerable nausea and vomiting from the onset of her pregnancy. She denied any attempt at interruption of her pregnancy. Her admission temperature was 102.6°F., pulse 120, respirations 24. Blood count showed 3,150,-000 red cells, 11.6 Gm. hemoglobin, 19,200 leukocytes, 73 per cent neutrophiles (38 filament, 35 nonfilament), sedimentation distance 110 mm. in one hour. Urine showed a trace of albumin, many leukocytes and erythrocytes. Vaginal examination revealed the uterus to be enlarged, with softened, enlarged cervix and patent canal; bleeding, with tissue protruding from cervical canal. The uterus was tender as were also the parametrial regions on both sides. Blood irradiation therapy was given on July 26. A blood culture was taken immediately before the irradiation treatment. This culture was negative. Routine curettement was performed immediately. Culture from the uterus showed Staphylococcus aureus in abundance. Blood culture taken immediately after operation showed indifferent streptococci. Blood culture taken July 31, showed no growth. At operation there was a profuse, bloody, purulent discharge from the cervical canal with an offensive odor. The cervix was very patent. The uterus contained a considerable amount of placental tissue with membranes; no fetus. The pathological report showed necrotizing placental tissue. As shown by the accompanying graph there was prompt recession of fever and pulse, and the patient made an uneventful recovery,

first pregnancy, was admitted to the Shadyside Hospital July 29, 1941. She gave a history of having last menstruated normally late in May, 1941, missed her June period, and approximately July 6; because she felt she was pregnant she began an attempt at interruption of her pregnancy. She admitted attempting to insert a slippery elm stick into her uterus each night for the next two weeks. She had a common cold at the time; no uterine symptoms developed until July 22, when she had frequent chills and a feeling of warmth. On July 23, moderate vaginal bleeding occurred but no cramps. That same evening she passed blood clots and tissue. On July 24, cramps developed, bleeding became worse, but no more tissue was passed. This bleeding continued rather moderately in amount until admission. On July 27, she was examined by her family physician who found a piece of tissue protruding from the cervix and prescribed ergotrate in the hopes the tissue would pass; however, such did not occur and, because the bleeding persisted, she was admitted as noted. Her admission temperature was not taken because of immediate operation. Blood count on admission was 4,300,000 red cells, 87 per cent hemoglobin, 13,650 leukocytes, 66 per cent neutrophiles (56 filament, 10 nonfilament). Vaginal examination revealed bloody vaginal discharge, nonoffensive, a piece of tissue protruding from the cervix, cervix softened, uterus enlarged and softened and moderately tender, no adnexal tenderness or enlargement. The same day of admission the

patient was given preoperative blood irradiation therapy. A blood culture taken immediately before blood irradiation showed no growth. Routine curettement was performed immediately, and a culture taken from the uterus which showed pneumococci of no specific type. A blood culture taken immediately after operation showed pneumococci of no specific type. At operation necrotizing tissue and membranes were removed from the uterus. No fetus was present. The pathological report showed necrotizing placental tissue. A blood culture taken July 31, showed no growth. As shown by the accompanying graph there was mild febrile reaction the next day to 100 degrees with prompt recession. The patient made an uneventful recovery and was discharged from the hospital on the fifth postoperative day, symptom free.

SUMMARY

The use of ultraviolet irradiation of autotransfused blood in postabortional sepsis has markedly influenced the prognosis in this pathological condition. We believe because of the histories of instrumentation, septic fever, pelvic complications and even septicemia very few of these patients would be considered in conventional surgical practice as safe operative risks because of the well grounded fear of spreading infection both locally and into the blood stream. Needless to say, the prevention of the prolonged morbidity, usually found in the conventional handling of such patients, alone is well worth while.

CONCLUSION

Twenty-one patients with postabortional sepsis were treated by ultraviolet irradiation of autotransfused blood. Our experience with this therapy in the treatment of postabortional sepsis prior to and after curettement indicates that in hemo-irradiation we have a valuable adjunct to the practice of surgery. Practically no increase in temperature was noted following surgery when hemo-irradiation was administered preoperatively. Definite protection was afforded against the usual disastrous spread of the uterine infection in the pelvis or into the blood stream. In cases of pronounced sepsis a remarkable reduction in the manifestations of toxemia was achieved. Ultraviolet irradiation of autotransfused blood used as an adjunct in the treatment of septic abortion should prove to be of inestimable value. The accompanying charts and histories* show the cases of postabortional sepsis treated by this method.

REFERENCES

1. BARRETT, HENRY A. Irradiation of auto-transfused blood by ultraviolet spectral energy: results of therapy in 110 cases. Med. Clin. North America, New York No., May, 1940.
2. BARRETT, HENRY A. The syndrome of the posterior inferior cerebellar artery. A. Cinelli. Arch. Otolaryngol., (in press).
3. BAYNE-JONES, S. and J. S. VAN DER LINGEN. The bactericidal action of ultraviolet light. Bull. Johns Hopkins Hosp., 34: 11–16, 1923.
4. CLARK, J. H., C. McD. HILL, M. HANDY, J. CHAPMAN and D. D. DONAHUE. Ultraviolet radiation and resistance to infection. Cong. Internat. Lum. Copenhagen, 458–463, 1932.
5. COBLENTZ, W. W. and H. R. FULTON. A radiometric investigation of the germicidal action of ultraviolet radiation. Sc. Papers Bur. Stand., 19: 641–680, 1924.
6. DOWNES, A. and T. P. BLOUNT. Researches on the effect of light upon bacteria and other organisms Proc. Roy. Soc., 26: 488–500, 1877.
7. HANCOCK, V. K. and KNOTT, E. K. Irradiated blood transfusion in the treatment of infections. Northwest Med., June, 1934.
8. HARRIS, D. T. Biochem. J., 20: 280, 271, 1926.
9. MACHT, D. I. The influence of ultraviolet irradiation of menotoxin and pernicious anemia toxin. Proc. Soc. Exper. Biol. & Med., 24: 966–968, 1927.
10. MAYERSON, H. S. and LAURENS, H. Am. J. Physiol., 86: 1, 1928; J. Nutrition, 3: 465, 1931.
11. NOGUCHI, H. The photodynamic action of eosin and erythrosin upon snake venom. J. Exper. Med., 6: 252–267, 1906.
12. MILEY, G. The ultraviolet irradiation of autotransfused human blood. Studies in the oxygen absorption value. Am. J. Med. Sc., 197: 873, 1939.
13. MILEY, G. Ultraviolet blood irradiation: therapy in acute pyogenic infection at Hahnemann Hosp., Hahnemannian Monthly, December, 1940.
14. REBBECK, E. W. Ultraviolet irradiation of autotransfused blood in the treatment of puerperal sepsis. Am. J. Surg., 54: 691, 1941.
15. WELCH, H. The effect of ultraviolet light on molds, toxins, and filtrates. J. Prev. Med., 4: 295–330, 1930.
16. WYCKOFF, R. W. G. The killing of colon bacilli by ultraviolet light. J. Gen. Physiol., 15: 351–361, 1932.

* Due to lack of space only the twelve most interesting case histories are included in this report. The remaining nine histories of cases 73902, 82877, 88216, 89680, 90031, 90388, 90760, 90827 and 90938 can be obtained at Shadyside Hospital, Pittsburgh, Pa.

THE MORTALITY OF CHOLECYSTECTOMY IN THE MALE*

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IN a recent review[1] comparing the statistics on gallbladder surgery performed in a general hospital and a private hospital in this community, a marked difference was noted in the mortality rate in cholecystectomy done on males. In these comparative series of 116 cholecystectomies done at the general hospital there were fourteen deaths, a mortality of 12.06 per cent. In the series done at the private hospital there were forty-five cholecystectomies with two deaths, or a mortality rate of 4.44 per cent.

In view of this striking variance in mortality an endeavor to explain this difference was attempted. Since there are many variable factors involved, a thorough analysis of all pertinent data was undertaken in the hope that the factors responsible for this variation might be found, thereby leading to a substantial reduction in the mortality of cholecystectomy in the male at the general hospital.

It is generally recognized that the mortality of cholecystectomy done on males is higher than that of the female, and also that the male is decidedly a poorer risk insofar as gallbladder surgery is concerned. Cole[2] states that the mortality in the male is 2 to 3 per cent higher than that in the female. Boyce, Veal and McFetridge[3] in an analysis of 404 consecutive surgical cases of gallbladder surgery, place the mortality in the male at 11.9 per cent as compared to 8.1 in the female. Boyd[4] has shown that the mortality in the male is decidedly higher than that in the female, and concludes that the male is a much poorer risk, the older the patient the higher the mortality.

AGE GROUPS

Possibly the fact that the male seeks surgical relief at a later date than does the female may be a contributing factor in the difference of the mortality rate for cholecystectomy between the two sexes; however, the slight difference in the average ages of the two hospital groups for male cholecystectomy cannot be a factor in accounting for the disparity in the mortality rate between the two institutions.

Although there is some variation in the comparative age groups as seen in Table 1, nevertheless, the average age of the patients at the general hospital was 48.56 years, while that at the private institution was 47.75 years, a difference of but .8 of a year, which is rather insignificant. (Table 1.)

PREOPERATIVE STAY

The average preoperative hospital stay at the general hospital was 11.13 days while that for the private institution was 2.6 days. The analysis of the preoperative hospital stay discloses one of the significant factors which definitely contributes to the difference in the mortality rate between the two institutions.

The majority of the patients (seventy-five or 64.65 per cent) were admitted to the general hospital during the acute phase of the disease. Of these eleven or 9.48 per cent of the total male cholecystectomy admissions were operated upon immediately with three deaths, a mortality rate of 27.27 per cent, or 35.34 per cent of the total cholecystectomy mortality. The remaining patients were held until subsidence of the

clinical symptoms and were operated upon during the quiescent stage.

Of the sixty-four patients remaining in the group ten died with a mortality of 15.62 per cent or 55.17 per cent of the total mortality. Of the forty-one patients admitted from the out-patient department for elective surgery, one died with a resulting mortality of 2.43 per cent or 9.48 per cent of the total mortality. However, this death was in a patient who had a cholecystostomy elsewhere, and was admitted with a biliary fistula for which surgical relief was sought.

cent of the total mortality. While it is well recognized that the clinical and pathological findings are not always in accord—for many gallbladders will show acute or subacute lesions when removed in so-called quiescent state—nevertheless, contrary to what one would expect, the findings of an acute or subacute lesion at the time surgery was instituted appears to be a minor factor in the mortality rate in this series.

In the private institution, however, forty-two or 93.33 per cent of the patients admitted for cholecystectomy were so-called elective out-patients, only three

TABLE I

AGE GROUPS

	20–29	30–39	40–49	50–59	60–69	70–79	Total	Average Age, Yrs.
General Hospital								
Number	8	19	36	26	25	2	116	48 58
Per cent	6 89	16 38	31 03	22 41	21 55	1 72		
Private Hospital								
Number	0	7	19	11	6	2	45	47 75
Per cent	0	15 55	42 22	24 44	13 33	4 44		

As shown above, the acute group of admissions, namely, seventy-five patients, accounted for over 90 per cent of the total mortality. Therefore, any improvement in the mortality rate of male cholecystectomy which can be made must be made in this group. Since eleven of the above group were operated upon as emergencies and were patients who were desperately ill, there is no doubt that a definite reduction in mortality rate can be accomplished by the performance of a cholecystostomy in place of cholecystectomy.

However, since the group which was operated upon immediately accounted for only 35.34 per cent of the total deaths a striking reduction in mortality rate can only be achieved by reducing the death rate in the group of patients who were operated upon after subsidence of the clinical symptoms and accounted for 55.1 per

being admitted during the acute phase of the disease. One of these was operated upon immediately, the preoperative diagnosis being perforated peptic ulcer, and the remaining two were operated upon a few days after admittance, the acute attacks being rather mild and subsiding rapidly.

Of the two deaths which occurred in the elective out-patient group one could possibly be classed as a surgical accident and in the second death the patient apparently was an extremely poor risk for the postmortem examination showed coronary disease, arteriosclerosis, fibrous myocarditis, recent myomalacia, bronchiectatic abscess of the lower lobe of the left lung; in addition the patient was diabetic.

Since the percentage of cholecystostomies performed at the private hospital is about 2½ to 1 performed at the general hospital, it appears that most patients with

an acute or subacute cholecystitis that are operated upon at the private hospital have a cholecystostomy performed.

PATHOLOGICAL LESIONS

In a review of this type the severity of the pathological lesion present at the time of the surgery must be given serious consideration for as a rule one would expect more deaths in the group in which the gallbladder was still acutely or subacutely inflamed at the time of its removal. We must also appreciate the fact that although the clinical signs have subsided, the gallbladder may still present signs of acute or subacute inflammation at the time of its removal. It is for this reason that sufficient time should elapse after the acute attack before instituting surgery to allow for complete subsidence or resolution of the pathological process.

However, in reviewing the pathologist's report in this series of cases one is forced to conclude that the acuteness of the lesion played a minor part in producing the difference in mortality between the two institutions.

In the three deaths occurring following surgery immediately upon admittance, the pathologist reported chronic cholecystitis in one, empyema in the second, and the report of the third was not available due to the fact that the patient had had a cholecystectomy elsewhere and was admitted to the general hospital for postoperative dehiscence and duodenal fistula.

In the group admitted for surgery from the out-patient department there was one death as mentioned. The patient had had a cholecystostomy elsewhere and was admitted for treatment of a gallbladder fistula.

The pathological lesions present in the patients who died following cholecystectomy at the general hospital after the subsidence of the clinical symptoms are as follows: chronic cholecystitis 5, subacute 2, hydrops 1, recent acute 1, and gangrene 1.

From the foregoing one is justified in concluding that the acuteness of the lesion can only be considered a lesser contributing factor.

TYPE OF OPERATION

In a review of the gallbladder surgery done at the general hospital covering a five-year period it was found that in seventeen surgical accidents in which the method of removal was stated the gallbladder was removed from the duct to the fundus in fifteen instances. Since the mortality rate of surgical accidents is near 50 per cent, the possibility that the type of operation may have been a contributing factor in the mortality rate must be considered.

However, in the analysis of the male cholecystectomy deaths from the series at the general hospital in which the method of removal was stated three were removed from the fundus to the duct, four from the duct to the fundus and in the remaining seven the method of removal was not stated.

As to the private hospital, in one death the method of removal was not stated and in the other the removal of the viscus was attempted from the duct to the fundus; but owing to the technical difficulties encountered this procedure was abandoned and the removal completed from the fundus to the duct.

From the above it would appear that the method of removal played no prominent part in the mortality rate as far as the general hospital is concerned, but apparently was a factor in the death at the private institution.

DRAINAGE

The failure to institute drainage played no part in the mortality rate for in the deaths at the general hospital eleven were drained, one not drained, and two were not stated. In the two deaths at the private hospital both patients were drained.

CALCULOUS AND NONCALCULOUS CHOLECYSTITIS

Although the mortality rate is higher in calculous than in noncalculous cholecysti-

tis, it appears from the comparative statistics to have played no rôle in the difference in the rate between the two institutions.

SECONDARY SURGICAL PROCEDURES

The most frequent secondary surgical procedure performed at both hospitals was appendectomy. As a rule the removal of an incidental appendix carries with it no additional risk as shown by Boyd.[4]

In the series of deaths at the general hospital appendectomy was performed in two patients while in the two deaths at the private hospital neither had had an appendectomy. However, *after completion of a* cholecystectomy an incidental appendectomy revealed a retrocolic abscess with resulting deaths of the patient.

In comparing the two groups of male cholecystectomies incidental appendectomy was performed in sixteen instances or in 13.79 per cent at the general hospital, while in the private hospital appendectomy was performed in twenty-four instances or 53.35 per cent.

From the comparative statistics incidental appendectomy of nonacute appendices played no part in the difference in the mortality between the two institutions.

However, the unfortunate experience mentioned could be avoided if the incidental appendectomy proceeds the cholecystectomy.

As to other surgical procedures in the combined groups there were two gastroenterostomies, one pyloroplasty and repair of two incisional herniae without a death. The secondary surgical procedure did not contribute to the difference in the mortality.

DEATHS

In the final analysis of the deaths at the general hospital the outstanding fact is that all the deaths but one occurred in the patients who were operated upon as emergencies or immediately following the subsidence of the clinical symptoms.

Since in the private hospital with the low mortality rate practically all male patients for cholecystectomy are admitted as ambulatory out-patients, one is compelled to conclude that the cholecystectomy should not be performed immediately upon subsidence of the clinical symptoms. These patients should be dismissed from the hospital for a period of six weeks to two months and an attempt made during the interim to improve the patients' general condition.

In classifying the deaths which occurred in the general hospital series the following causes are found: bronchopneumonia three, postoperative hemorrhage three, retrocolic *abscess one, acute cholecystitis* one, *aspiration* pneumonia one, subphrenic abscess three, duodenal fistula one, pyemic abscess of kidney one.

Thus it appears as though the infection was responsible for nine deaths, hemorrhage for three, questionable postoperative care for one, and surgical accident for one.

Since next to infection postoperative hemorrhage played an important part in the mortality, it appears quite likely that this complication is far more frequent when surgery is performed immediately after subsidence of the clinical symptoms.

CONCLUSIONS

The death rate in male cholecystectomy can be appreciably reduced by the proper application of certain sound surgical principles in which controllable circumstances appear to be a definite contributing factor to the mortality:

1. All patients who are admitted as emergencies and not operated upon as such, should be dismissed from the hospital after subsidence of the clinical symptoms and be readmitted at a later date for surgery as ambulatory elective patients. A minimum time of six weeks to two months should be allowed to elapse before surgery is instituted during which time the patient's general condition should be improved as much as possible.

2. If a patient is being operated upon for cholecystitis and the findings upon opening

the abdomen are such to cast doubt on the diagnosis, exploration of the abdomen should precede the cholecystectomy.

3. Removal of an incidental appendix should precede the cholecystectomy.

4. If the gallbladder appears acutely inflamed at the time of an elective cholecystectomy, cholecystostomy is the operation of choice.

5. The more frequent removal of the gallbladder from the fundus to the duct will reduce the number of surgical accidents and thereby contribute to the reduction of the mortality.

6. The routine use of the Levine nasal tube would no doubt not only aid in preventing aspiration pneumonia, postoperative vomiting, gastric dilation, and abdominal distention, but also reduce the percentage of postoperative herniae.

Although the above conclusions are undoubtedly open to criticism, nevertheless, the recommendations and conclusions enumerated quite likely will reduce the mortality rate in cholecystectomy done in the male in the hands of the average surgeon.

REFERENCES

1. Bachhuber, Carl A. *West. J. Surg.*, 49: 203–207, 1941.
2. Cole, Warren H. *Internat. Abstr. Surg.*, 69: 40–46, 1939.
3. Boyce, Frederick Fitzhubert, Veal J. Ross and McFetridge, Elizabeth. *Surg., Gynec. & Obst.*, 63: 43–53, 1936.
4. Boyd, Philip. *New England J. Med.*, 218: 1045–1050, 1938.

Correction: In our January (1942) issue an article was published entitled "Stab Wound of the Heart" by Dr. Robert E. Carter. The author now wishes to correct his original legend to Figure 3 on Page 145. It should read: "Patient sustained stab wound of heart. He was operated upon in June, 1938. This picture was taken ten days postoperatively."

ABDOMINAL NEURALGIA IN RELATION TO THE SUPERFICIAL ABDOMINAL NERVES*

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A PRECISE knowledge of the distribution of the nerves of the abdominal wall is of great aid in the

FIG. 1. Points at which the nerves of the abdominal wall become relatively superficial. Distribution and main nerve components indicated.

intelligent handling of abdominal pain of neuralgic origin. It is commonly recognized that the lower intercostal and upper lumbar nerves supply cutaneous and other branches to the abdomen. When it is known where these branches lie, it is possible to strengthen the diagnosis of neuralgia by pressure over them. However, in no discussion of this subject consulted, is there an attempt to locate the branches for this purpose. It should be emphasized that they are mixtures of filaments of the lower intercostals, iliohypogastric and ilioinguinal containing fibers from the seventh thoracic to the second lumbar nerves.

ANATOMY

The numbered triangles of Figure 1 represent the points where the superficial nerves of the abdominal wall first come to lie, fully formed, beneath the aponeurosis of the external oblique. Their distribution is indicated by shading. The points have been numbered to clarify explanation of the cases presented. Most textbooks of anatomy draw these nerves in diagrammatic fashion and give a less exact description of their distribution than is merited by their size and constant position. They are described here as established by cadaver dissection;† in the living subject, their positions may be verified by eliciting hyperesthesia on pressure over them just as pressure over other sensory nerves produces an uncomfortable hyperalgesia.

Points 1, 2, 3 and 4 lie along the abdominal margins of the eighth, ninth and tenth costal cartilages. Point 5 lies just below the end of the eleventh rib. Point 6 lies at the tip of the twelfth rib. Point 7 is midway between 6 and 8; point 8 is just above the highest part of the crest of the ilium; point 9 lies just above the iliac insertion of the inguinal ligament, and point 10 at the midpoint of the inguinal canal.

In our cases of abdominal neuralgia, the pain lay in the areas indicated by shading for each branch involved. Search for and pressure on the corresponding nerve points, gave corroboration of the diagnosis; these were exquisitely tender. Points 6, 7 and 8 were the most commonly involved.

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INJECTION

Advantage is taken of the rather superficial position of the nerves in confirming the diagnosis by procain block. They can be reached by a hypodermic needle, long or short depending on the pannicular thickness. The position of the most tender spots, corresponding to the numbered triangles of Figure 1, are marked with colored skin antiseptic and a skin wheal raised with procain.

The needle is inserted until it passes through the deep fascia; it is important that it penetrate this tissue since the nerve lies beneath. The nerve may be searched for by probing with the tip although this is not necessary. Two cc. of procain should suffice to relieve the abdominal pain within a minute.

In our hands, relief has been complete enough to establish the diagnosis, but has been so temporary (three to four hours) that we routinely follow with from 0.5 to 1.0 cc. of 95 per cent alcohol. If there is a burning sensation, a few more drops of procain will alleviate it.

DISCUSSION AND CASE REPORTS

The procain-alcohol technic has proved diagnostically positive and therapeutically easy in seven cases of abdominal neuralgia seen in a six-month period in clinic and ward practice; private cases have not been included in this survey. The number of cases is probably larger than will be seen in a similar period hereafter, since many have gone undiagnosed from clinic to clinic for several years. Cases are presented in Table 1.

It is interesting to note that five of the seven cases showed a spinal abnormality. Three of the patients x-rayed had spondylitis and one a unilateral iliac wedging. One other patient had a postural scoliosis due to shortening of one leg. All were accompanied by genitourinary disease, but none of a degree severe enough to account for the amount of associated pain.

TABLE I

Patient	Location of Pain	Duration of Pain	Previous and Concurrent Diagnoses	Points Injected	Solution Injected	Date	Relief
1. *h91595, W. M. age 68	right abdomen	3 years	prostatic hypertrophy, ureteritis, vesiculitis, acute upper abdomen, marked spondylitis	R7, 8, 9 R7, 8, 0 R3, 4, 5, 6	procain procain-alcohol procain-alcohol	4-23-40 4-30-40 5- 3-40	temporary permanent permanent
2. *h5610, *e11333, W. M. age 39	right flank and right lower quadrant	8 years	pyelitis, appendicitis, colitis, lues, anemia, hemorrhoids	R5, 6, 7 R8	procain-alcohol procain-alcohol	5-28-40 6- 3-40	permanent permanent
3. *c15591, W. M. age 34	right flank, right hip and thigh	5 years	pyelitis, prostatovesiculitis, healed fractures of second and third lumbar bodies	R7, 8 R7, 8	procain procain-alcohol	6-24-40 7- 2-40	temporary permanent
4. *c13306, *h92732, W. F. age 19	l. abdomen	3 years	salpingitis, endometritis, postural scoliosis and lordosis	L7, 8 L7, 8 L6 L5	procain procain-alcohol procain-alcohol procain-alcohol	9- 9-40 9-16-40 9-23-40 10-21-40	four hours four hours unsatisfactory unsatisfactory
5. *h01365, W. F. age 54	l. hypochondrium, l. hip and thigh, l. abdomen and flank	2 weeks	nephroptosis, spondylitis	L6, 7 L6, 7 L8	procain procain-alcohol procain-alcohol	4- 8-40 5- 6-40 10- 4-40	temporary permanent permanent
6. *c15126, W. M. age 28	left lower quadrant	2 weeks	incipient l. hernia, urethral stricture	L7, 8	procain-alcohol	10-15-40	permanent
7. *h0386, *c15013, W. F. age 22	right abdomen	1 year	pyelitis, appendicitis, salpingitis, sacro-iliac abnormality	R4, 5, 6, 7	procain-alcohol	8-19-40	four days

Remarks.

1. (W. S.) Fifth l. intercostal injected at midclavicular line, 12-3-40, for "heart pain."
2. (S. L.) Slight return of pain during heavy work. Had not worked for eight years.
3. (P. K.) Lateral femoral cutaneous nerve injected (in quadratus m.) at same time.
4. (H. K.) Pressure points insensitive after treatment, but pain persisted in left rectus region.
5. (M. B.) Pain of upper abdomen and hip, less severe, abated between injections.
7. (S. H.) Negative laparotomy, 9-6-40, pain persists (response to questionnaire).

That the described method is not therapeutically perfect can be seen by our failure to achieve lasting relief in two cases. Case 4 has been relieved by orthopedic measures. Case 7 has not returned, following a futile laparotomy. Her pain was stopped for only four days in the region injected. While such cases demonstrate the diagnostic value of superficial injection, they also emphasize the extent to which the syndrome requires general, as well as local treatment. The possibility of an induced alcoholic neuritis should mitigate against repeated injection.

SUMMARY

1. The diagnosis of abdominal neuralgia may be strengthened by finding markedly increased tenderness over the superficial nerves of the abdominal wall.

2. The position of these nerves is located and described.

3. Procain injection at the described points relieved neuralgic pain in seven cases presented. Permanent relief was obtained by addition of alcohol in five cases.

Correction: In the December (1941) issue of the American Journal of Surgery there appeared a paper on "Postoperative Evisceration" by Dr. Morris L. Bobrow in which the statements were made " . . . there is no legal standard of catgut gauge and strength in the United States," and " . . . most companies have adopted the Federal specifications as their standard," which specification, it is pointed out, has no legal status.

This is incorrect. Under the new Food & Drug law, all catgut standards as published in the U. S. Pharmacopoeia, Second Supplement of the 11th Revision, have been mandatory standards on all manufacturers. Material which does not measure up to these standards is subject to seizure by the Department of Agriculture; in fact, most governmental agencies have adopted these U.S.P. standards. These U.S.P. standards have been in effect for nearly a year and a half.

ACUTE APPENDICITIS IN CHILDREN*

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THIS study of acute appendicitis in children is based on 293 consecutive cases occurring on the Children's Surgical Service at Bellevue Hospital for the five-year period from 1936 to 1940, inclusive. Comparisons are made to a similar report made by the writer,[1] in 1937, covering the ten-year period from 1926 to 1935, inclusive. All children included in this series suffered from acute inflammation of the appendix, confirmed pathologically. The same group of surgeons operated upon these patients, and the same method of classification has been used as in the preceding series, namely, (1) unperforated; (2) abscessed; and (3) spreading peritonitis.

The previous series consisted of 612 patients, among whom there were thirty-six deaths, or a death rate of 5.8 per cent. Beekman[2] made a still earlier report of 145 cases from this service, with a death rate of 7.58 per cent. The present group consists of 293 patients, with five deaths, or a death rate of 1.7 per cent. Among these children there were thirty-one who had not reached their fifth birthday, with one fatality. This mortality rate of 3.2 per cent for infants and younger children compares favorably with a mortality rate of 25.6 per cent for the same age group reported by Beekman,[3] and which has been reduced to 15.2 per cent in my last report.

This marked improvement in mortality statistics leads to a consideration of the factors we deem responsible. These should be divided into two groups: First, those occurring before the patient entered the hospital, and, secondly, the preoperative, operative and postoperative management of these children. It is noted that the patients in this series applied for admission to the hospital on an average of thirty-four hours after the onset of the disease, whereas in the old series fifty-two hours had elapsed. The factor of catharsis also shows a trend in the right direction. Forty-nine per cent of the patients in the previous series had received cathartics, whereas in this series it has been reduced to 36.8 per cent. This would seem to indicate that the attempt at education of the public by radio and public press is bearing fruit.

In the previous series, 51 per cent of the patients were in the unperforated group, the rest being almost equally divided between spreading peritonitis and abscess groups. In this series, 66.5 per cent were unperforated at the time of operation. The earlier admission of these children, and the fewer who had had cathartics administered, most likely accounts for the greater number being in the less serious group.

The preoperative management of these patients has materially changed since my last report. In the former group of patients the average time elapsing between their admission to the hospital and the operation was 3.9 hours. In this group the time was almost doubled, 7.5 hours having elapsed. We have, therefore, been much less hasty in getting these patients to the operating room. We still aim at immediate operation in a child suffering from early acute appendicitis who is in good fluid balance. However, in children with evidence of spreading peritonitis who are dehydrated from long continued vomiting, we find much has been gained by a few hours of preoperative management aimed at correcting fluid balance. While this is being done the distention may be reduced by the use of a Levin tube attached to a Wangen-

steen suction apparatus, together with general supportive treatment. Blood transfusions are occasionally administered at this time. The majority of these children are changed from very poor operative risks to relatively good ones in six to eight hours. In the old series preoperative infusions were rarely if ever administered, whereas in this group eighty-five patients or 29 per cent of them received one or more preoperative infusions, usually with normal saline and 5 per cent glucose. In very few instances in which this procedure was followed did we note a tendency for the clinical appearance to become worse.

In not a few children, admitted with a diagnosis of appendicitis with spreading peritonitis, we were able to correct our diagnosis while fluid balance was being established. The diagnosis of primary peritonitis of either pneumococcic or streptococcic origin has frequently been made during this time and premature operation thereby avoided.

The technic of the operations in this group has not varied much from that in the previous one, except that in that group a right rectus incision was used in 95 per cent of the cases, whereas in this group it was employed in only 7 per cent. A McBurney incision was used in 93 per cent of this series. This incision provided a more direct approach to the diseased appendix together with less trauma to the uninfected portions of the peritoneal cavity. In cases in which drainage is employed it decreases the chance of the drain lying in contact with a clean loop of intestine, as was frequently the case when a right rectus incision was used. The method of handling the stump is about equally divided between inversion and simple ligation. The condition found at operation frequently decides this procedure. In cases in which drainage is expected to be extensive, we have continued to be enthusiastic with the practice whereby only the peritoneum is closed with interrupted sutures down to the drain and the remaining layers of the abdominal wall left open to be packed loosely with vaselined

gauze. More recently, in patients presenting evidence of early peritonitis in which the fluid is turbid but not actually purulent, we frequently close the peritoneum without drainage and leave the other layers of the abdominal wall open. To date we have had no reason to regret this procedure but our experience has been insufficient to comment positively on its value.

In eight instances in this series the appendix was not removed at the time of operation. These were all in patients who presented large thick-walled abscesses, and drainage was instituted attempting to preserve as much as possible nature's architecture of the cavity. Seven of these children recovered and one died. Of the seven who recovered four returned in about three months for appendectomy. Two have been lost to follow-up and the other one is symptom free. We always advise the parents that the appendix has not been removed and urge its removal within a few months.

Anesthesia. In 1935, the anesthesia department at Bellevue Hospital was reorganized under the directorship of Dr. E. A. Rovenstine. All anesthesias are administered by the physician-anesthetists under his direction. No fixed opinion is held as to the best anesthesia for appendectomy but consideration is given to the physiologic disturbances that are present. Every patient is individualized as to the proper anesthetic procedure. Children six years of age and over are prepared with morphine and atropine or scopolamine, whereas infants and younger children receive atropine only. The carbon dioxide absorption technic is usually employed since with its proper application oxygen want and carbon dioxide excess are eliminated, respirations are more like those of normal sleep and adequate relaxation is secured with a minimum of agent. Ether and cyclopropane are the drugs most often employed and nitrous oxide is used only for induction.

During operation the airway is kept unobstructed; the status of the circulation

is followed at short intervals with determinations of the blood pressure and pulse rate. Treatment is immediately instituted to prevent serious consequences from such emergencies as circulatory collapse, vomiting, excessive mucus or increasing body temperatures.

We are convinced that the advances made by the anesthesia department played a big part in our lowered mortality rate as well as the improvement in morbidity. Postoperative pulmonary complications have been reduced to a minimum. No patients has been lost on the table, and none of the deaths in this series can be attributed in any way to the anesthesia.

In the previous group of patients twelve, or one-third of the thirty-six deaths, occurred within twenty-four hours after operation. One patient died on the operating table, one died within twelve hours of shock, and in all the others profound toxemia was noted, with several expiring before reaction from anesthesia was complete. We believe that with the present preoperative care aimed at correcting fluid balance, together with the improved methods of anesthesia, many of those deaths might have been averted.

The postoperative management of these children has not changed materially except that we are definitely more alert in watching for clinical and laboratory evidence of fluid imbalance. There is also a tendency to the earlier use of the Levin tube, more as a preventive of distention than as a cure for long continued distention, as was the practice in the earlier days. Blood transfusions have been administered more freely. Oxygen therapy has been employed in a few cases in which there was extensive peritonitis. The sulfonimide drugs have been used in the majority of cases with spreading peritonitis and, more recently, in a few instances we have used sulfanilamide locally in the peritoneal cavity and in the operative wound. We have not been impressed with this drug as influencing the course in any of these patients. However, it has been used in too few to draw definite conclusions.

The number of days in the hospital has been reduced in this series as compared to the old, the previous group having remained in the hospital on an average of 21 days, whereas in this group it was only 15.6 days. We believe this can be chiefly attributed to the use of the McBurney incision in addition to the fact that in a larger percentage of the patients the appendix was not perforated at the time of operation.

Unperforated Group. There were 195 cases, or 66.5 per cent of the series, in which the appendix was not perforated at operation. These children had been ill on an average of 27 hours at the time of admission, and an average of 6.8 hours transpired from admission to operation. One death occurred in this group.

CASE I. T. N., a white, female, age nine, complained of generalized abdominal pain and vomiting for four hours. She had suffered three previous similar attacks. There was local tenderness over McBurney's point. Her temperature was 99°F.; leukocytes 13,100, 89 per cent polymorphonuclears. She had a mild head cold but appeared in good general condition. She was operated upon within two hours of admission. An acute, unperforated appendix covered with fibrin was removed through a McBurney incision, the stump being inverted. A small rubber dam drain was inserted down to the peritoneum at the lower angle of the wound. The fever rose to 103°F. within twenty-four hours and remained high. Distention became marked on the third day. All sutures were removed and extensive fascial slough was present on the fourth day. The Wangensteen suction apparatus was used together with hot stupes and repeated enemas. She died on the thirteenth postoperative day, apparently of diffuse peritonitis.

Abscess Group. Twenty-six patients presented abscesses at the time of operation, which was performed on an average of 14.7 hours after admission. These children were admitted eighty-eight hours after the onset of their disease, which is a marked

reduction from the one hundred forty-seven-hour average in the same group of the previous series. One fatality occurred in this group.

CASE II. L. P., a male, age nine, had been ill five days with abdominal pain which at first was general and later became localized. He had not vomited. A previous similar attack had occurred one month earlier. A cathartic had been administered in this instance. His temperature was 100.6°F.; leukocytes 12,700, 83 per cent polymorphonuclears. The abdomen was moderately distended. Tenderness and rigidity were localized to the right lower quadrant. Through a McBurney incision, a thick-walled abscess was found in the right gutter. No attempt was made to remove the appendix but the abscess was drained and the abdominal wall left open. After operation, distention persisted, drainage was never satisfactory and on the ninth day the temperature rose to 106°F. An ileostomy was then performed but no drainage was obtained. He expired on the twelfth postoperative day. Autopsy revealed a diffuse peritonitis.

Spreading Peritonitis. Seventy children in this series presented spreading peritonitis at the time of operation. This was 24.5 per cent of the entire group, which is the same proportion with this phase of the disease as was noted in the previous series. These patients were admitted on an average of thirty-four hours after the first symptom was observed, and six and eight-tenth hours was consumed in preparing them for operation. There were one operative and two nonoperative deaths in this group, a mortality rate of 4.2 per cent.

CASE III. T. V., a white, male, age ten, had suffered generalized abdominal pain without localization and vomiting for eighty-two hours. He had been given a cathartic and repeated enemas. His temperature was 101°F.; leukocytes 18,200, polymorphonuclears 82 per cent. He was dehydrated and his abdomen was distended. There was generalized abdominal rigidity. A mass was palpated by digital examination of the rectum. A gangrenous perforated appendix with spreading peritonitis was found at operation, a right rectus incision being employed. A drain was placed into the

pelvis and one into the right gutter, the peritoneum being closed about the drains. The rest of the abdominal wall was left open. The course was rapidly downhill, with high fever, uncontrollable distention, and rapid respirations and death occurred on the fifth postoperative day. No necropsy was obtained but death was obviously due to diffuse peritonitis.

Nonoperative Deaths. CASE IV. B. C., a white, female, age two and one-half years, had had a severe cold with cough for two weeks. For forty-eight hours there had been anorexia, vomiting and fever. No history of pain could be elicited. Her abdomen was rigid throughout. Her temperature was 103.6°F.; pulse 144; leukocytes 18,800, falling to 8,800 in twenty-four hours. She was dehydrated and toxic. The patient did not improve with infusions, transfusion and sulfanilamide therapy but became rapidly worse, dying fifty-seven hours after admission. Necropsy revealed a general peritonitis with a ruptured appendix lying in an abscess cavity in the right gutter. One naturally speculates as to the result had drainage been instituted within a few hours after admission. From the rapid downhill course presented by this infant it is doubtful that operation would have influenced the outcome.

CASE V. A. F., a white, female, age six, had had generalized abdominal pain and vomiting for fifty-six hours previous to admission. Her temperature was 104°F.; pulse 130; leukocytes 19,000, 86 per cent polymorphonuclears. The abdomen was distended and rigid throughout. The father refused to allow operation in this instance. Morphine sulfate in $\frac{1}{12}$ gr. doses was administered every four hours. Infusions, one transfusion, and sulfanilamide were given. A peritoneal tap revealed a Gram-negative bacillus. She died in forty-six hours, the course being progressively downhill. Autopsy revealed a generalized peritonitis, the tip of the appendix being gangrenous and perforated. There had been no attempt at any localization.

Complications. The convalescence of these patients has been noticeably smoother than in the previous group. Serious complications have been few. Pneumonia occurred in only two patients, and one of the older children had a definite atelectasis. All of these recovered. Retention of pus in the pelvis occurred in eleven instances. All of these recovered without any secondary

operative procedure, most of them draining through the original drainage sinus. Four of these drained spontaneously through the rectum. All of them were treated with hot rectal irrigations, twice daily, in addition to poultices or stupes to the abdomen.

A fecal fistula occurred in one patient, which closed spontaneously. This patient also developed a phlebitis of the right saphenous vein but was discharged in good condition on the thirtieth day after operation.

Partial dehiscence occurred in two patients in both of whom only the peritoneum had been closed. In one instance a loop of small intestine presented and was packed back with vaselined gauze. The wound healed firmly. In the other case through-and-through silk sutures were used after the small intestine and omentum were replaced. The wound in this patient was healed on discharge but the case has been lost to follow-up.

Retention abscesses have continued to be a common complication. They occurred in fifteen instances in which the wound had been closed without drainage, necessitating opening the wound widely down to the fascia. In one of these patients there was a large abscess in the right iliac fossa. There were 135 patients who were closed without drainage. We, therefore, had an infection rate of 11.1 per cent as compared to 25.6 per cent in the old series. In eleven instances among thirty-eight cases, in which there had been a small drain placed down to the peritoneum, it was later necessary to open the wound for more adequate drainage.

In one patient in whom a McBurney incision was used and the wound left open, a severe hemorrhage occurred about twenty-four hours later. The wound was packed. Four transfusions were administered, and he was discharged with the wound completely healed on the thirty-sixth day. One child suffered a severe iodine burn of both groins.

Follow-up. We were successful in following 80 per cent of our patients in the Follow-Up Clinic. In this series there have been three postoperative herniae. In four instances a bulge and slight weakness were noticed during the first few months of observation, only to disappear at the end of the year. Since 1926, we have been successful in following 220 patients in whom only the peritoneum was sutured down to the drain at the time of operation. There have been seven herniae in this group, an incidence of 3.1 per cent. During that same period, 187 patients have been followed-up in whom drainage was instituted by the old method, namely, the suturing of all layers of the abdominal wall down to the drain. Eight herniae were noted among these, an occurrence rate of 4.2 per cent.

SUMMARY

Two hundred ninety-three children suffering from acute appendicitis have been analyzed. Five deaths occurred in this group, two of which were nonoperative. This is a marked reduction in death rate as compared to previous reports from the same service. Among the outstanding reasons assigned for the lowered mortality rate are: (1) earlier hospitalization; (2) fewer cathartics; (3) more preoperative care aimed at correcting fluid balance, especially in toxic dehydrated patients with evidence of spreading peritonitis; (4) better anesthesia and (5) the use of the McBurney incision. This incision is likewise believed to have been the chief factor in reducing hospital stay from twenty-one days in the previous report to fifteen and six-tenth days in this series. Further follow-up observations in cases in which drainage was employed and in which only the peritoneum was sutured is reported, with a decreased incidence of hernia in this group.

REFERENCES

1. ALLEN, P. D. Acute appendicitis in children. *J. A. M. A.,* 109: 121–125, 1937.
2. BEEKMAN, F. Acute appendicitis in childhood. *Ann. Surg.,* 79: 538, 1924.
3. BEEKMAN, F. Acute appendicitis in the infant. *Ann. Surg.,* 80: 911, 1924.

GASTRIC RESECTION FOR ULCER*

EXPERIENCE IN FORTY-FOUR CASES

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THE trend toward high resection for ulcer is justified by the increasingly favorable long range results as compared with those following lesser operations, together with a lowering mortality rate as wider experience is obtained.

This series of forty-four cases is reported, not because of any excellency of results, but to suggest certain factors which we believe have enabled us to operate upon these patients more safely. It is recognized today that our medical colleagues can treat successfully over 85 per cent of duodenal ulcers. It is with the small fraction who cannot be relieved by conservative measures that we are concerned.

It is constantly asked why some cases are so resistant to treatment when the great majority are controlled. We cannot answer this question completely. Possibly all would be amenable to a rigid régime instituted early in the disease. However, the local duodenal pathological condition seen at operation is enough to explain such resistance. In all of the patients upon whom I have operated for this reason there has been a more or less extensive duodenitis with an open ulcer appearing only as an area of greatest acuteness. Without exception all have been adherent to the pancreas. The wall has been thickened and stippled over a wide area. When the duodenum has been opened, the rugi have appeared less free, thickened, often the entire mucosa looking much like granulation tissue.

These duodenal walls may be compared to the leg which has been the site of repeated varicose ulcerations or to one which has healed after being severely burned.

Slight trauma which would go almost unnoticed on the normal leg will produce a stubborn ulcer. I believe we should quit thinking and saying "This patient's ulcer has become active again." It is in all probability not the same ulcer. He has a new ulcer in that chronically diseased duodenum. Part of this pathological condition is due to repeated ulceration and healing with deep scar tissue replacement. Multiple ulcers are not uncommonly observed. In one patient operated upon recently the probable location of two previous perforations could be seen and there was an active ulcer on the posterior wall. In ten cases of resection in which the patients had had free perforations an active ulcer was present posteriorly.

It is suggested that all of these individuals who cannot be maintained in reasonable health and comfort by the internist have such irreversible pathological changes in the duodenal wall, and especially over the pancreas, that the slightest exciting cause will produce an ulcer which can be healed only with great difficulty, if at all, and with further damage to the wall. I do not know why some reach this unfortunate state, but it is easy to see why they can find relief only at the hand of the surgeon. Appreciation of this existing condition is necessary to a wise choice of surgical procedure.

Since the internist has treated ulcer with such a high measure of success, we surgeons will do well to consider what he does and seek to emulate it. There are four local conditions which he considers and attacks more or less directly by various means.

These conditions are (1) pylorospasm, (2) hypermotility, (3) hypersecretion, and (4) hyperacidity. (Fig. 1A.) If these can be

that since these results must largely be obtained indirectly they are apt to be more or less incomplete. That this is true is
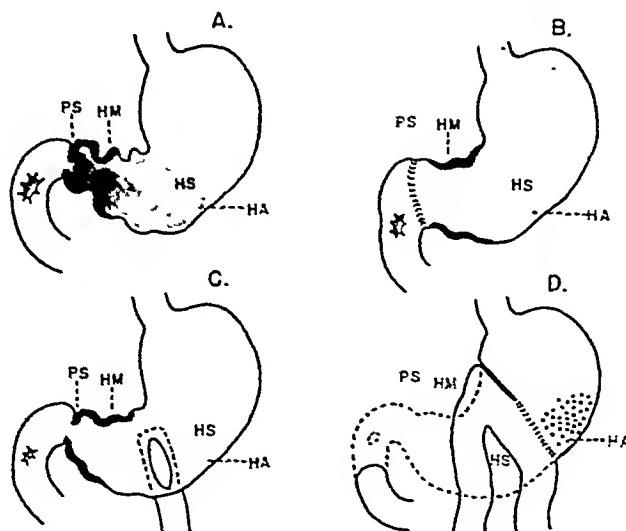
FIG. 1. PS, pylorospasm; HM, hypermotility; HS, hypersecretion; HA, hyperacidity. Depth of shading suggests degree of hyperacidity and hypersecretion. A, the stomach with active duodenal ulcer; B, after pyloroplasty; C, after gastrojejunostomy; D, after resection, which removes all factors.

continuously controlled, the ulcer usually heals and does not recur as long as this control is maintained.

How are these four treatment demands met by our standard operative procedures?

1. *Pyloroplasty* is a fairly commonly performed operation. (Fig. 1B.) This, it would seem, certainly once and for all eliminates pylorospasm by destroying the pyloric sphincter. One who has seen many stomachs, particularly under spinal anesthesia, has noted the spasm of the prepyloric area, and is justified in wondering just how much is actually accomplished by the average pyloroplasty. Finney and Horseley must have had this in mind when they devised their operations for both insisted that the incision be carried well up into the prepyloric portion of the stomach.

In addition to the elimination of pylorospasm, pyloroplasty is supposed to meet the other indications by permitting free back flow of alkaline duodenal contents to reduce acidity, and by the unobstructed wide opening which removes some of the reason for hypermotility as well as the effects of hypersecretion. It can be seen

evidenced by the failure of pyloroplasty to cure the patient in too many cases. We have found ulcer recurring just a little further down beyond the old suture line.

In the presence of the duodenal pathological condition existing in these patients, it is an extremely optomistic surgeon who will expect this operation either to be satisfactorily performed or to give permanent relief.

If there is truth in the Edkin's hypothesis of an acid stimulating hormone in the antral mucosa, pyloroplasty leaves the patient no better off as far as his acid is concerned.

2. *Gastrojejunostomy* is supposed to eliminate vicariously the effects of pylorospasm as a result of the short circuit, and meet the other indications in much the same way as pyloroplasty, that is, by intragastric regurgitation and freer emptying. (Fig. 1C.) This again is an indirect means of attacking the problem. It is notoriously ineffective in the presence of high acidity and the absence of obstruction. Too often the patient is given a jejunal ulcer and his second state is worse than the first. He will

devoutly wish he had his duodenal ulcer back instead.

3. *High resection* completely eliminates all of these factors directly and permanently, and is, I believe, the only way in which most patients can be permanently cured. (Fig. 1D.) In the occasional case in which jejunal ulcer is reported following this operation, there is often doubt as to whether resection has been high enough. One should not be satisfied with removal of less than three-fourths of the stomach. All of our cases have been followed and no jejunal ulcer has occurred thus far.

Part of our duty is to improve our results individually and collectively. To this end I am confessing certain errors in technic and judgment. In forty-four resections for ulcer there were six deaths, a mortality rate of 13.6 per cent which is entirely too high. That we have profited by these mistakes is shown by the fact that in our last twenty-nine resections for all conditions there have been only two deaths,* one of which occurred in a man eighty years old with cancer.

The first death was due to breaking down of the anastomotic suture line. At that time only two rows of sutures were being used. Since then a third has been added and this disaster has not recurred. The VonPetz clamp has been of major value in facilitating high resections. The second death was due to poor judgment in attempting to do an exclusion after division just through the pyloric ring. The duodenal pathological condition described above was present and one should not expect it to hold. It did not hold. The next was somewhat similar in that not enough duodenal wall was separated from the pancreas to make closure of the stump secure. We have since learned to place a finger inside the duodenum as a guide when this dissection is difficult. Another fatal case presents an interesting question. There was a small fistula between the gallbladder and the duodenum. The gallbladder wall appeared

quite normal and the opening in it was inverted and closed. It opened, a subdiaphragmatic abscess formed and was drained, but death occurred two months later from a liver abscess. If the gallbladder had been removed or drained or even had an exclusion been done, this patient would almost certainly be alive.

Two of the six deaths were caused by pulmonary complications, one on the seventh day due to pneumonia, the other on the thirtieth day due to multiple pulmonary abscesses following massive atalectasis. Both of these cases had intratracheal anesthesia. This method was used in eight of this series with seven major respiratory complications and three deaths. In one, however, the primary cause was abdominal and is described above. Intratracheal anesthesia has not been used since and no pulmonary deaths have occurred. I do not wish to decry the method which is invaluable in certain conditions, but in my hands it has been followed by a prohibitive rate of respiratory complications.

Twenty patients, or 45.4 per cent of this series, had had together twenty-seven previous operations for ulcer. There were twelve closures of acute perforations (two had had two), six gastrojejunostomies (one case had had two), three pyloroplasties, two degastroenterostomies, one antrumectomy, one excision of ulcer, one partial cholecystectomy and one exploration with appendectomy. Five of the six deaths occurred in this group.

There are seven resections for exclusion with one death referred to above. In the six recoveries the antral mucosa was not removed. All are clinically well, one after four years, the others for a shorter time. Three have shown no free acid after alcohol or histamine stimulation. We have not yet succeeded in getting determinations in the others. These results do not tend to support the Edkin's hypothesis, but the time following operation is admittedly too short for final conclusion. While we think the patient is safer with the pylorus and the first portion of the duodenum removed, when

* On January 7, 1942, forty-two consecutive resections for ulcer had been completed with one death.

the risk seems too great we shall probably continue to do an occasional resection for exclusion, adding, however, excision of the antral mucosa.

The operation has been completed with antecolic anastomosis without enteroenterostomy seventeen times. The patient who developed liver abscess is the only death in this group. In addition, seven have been done following resection for carcinoma. All have had good functional results, including the one who died two months later. The first one was done six years ago. X-ray studies in eight of them have shown no tendency toward stasis in the proximal loop. It has been hard for surgeons to get away from the idea that gravity plays an important rôle in the forward movement of intestinal contents. If the terminal ileum, cecum and ascending colon have no difficulty in transporting their load from the bottom of the pelvis to the hepatic flexure, why should we question the ability of the jejunum to do much less? In twenty-four cases the anterior anastomosis has functioned with complete satisfaction. It is simpler, easier, and therefore more quickly done. The difficulty of attaching the transverse mesocolon to the stump of the stomach after a high resection is eliminated, together with the possibility of proximal loop obstruction. Should subsequent operation be necessary the problem is much simpler. This was experienced in one patient who had had an antrumectomy and anterior anastomosis. We operated three years later for jejunal ulcer with much less difficulty than a posterior anastomosis would have caused. We believe at present that there are only three situations in which retrocolic anastomosis may be preferable: First, when resecting for jejunal ulcer following posterior gastrojejunostomy in which the opening in the transverse mesocolon is already present; second, when

there is an unusually long transverse mesocolon, and third, when the jejunal mesentery is usually short. In some of the first the anterior method will be preferable.

Restoration of gastroduodenal continuity by some form of the Billroth 1 method has not been used in any cases of ulcer, though we have occasionally used it in cancer. The duodenal pathological condition increases the immediate operative risk as well as that of recurrence. The temptation must also be present to remove less of the stomach to facilitate the operation and prevent tension.

There still exists much difference of opinion as to the best plan for the surgical treatment of ulcer and also in detail of technic. I close by making a plea that results be reported frankly, the bad, which we hesitate to publish, as well as the good. Only in this way can we reach the goal of reasonably safe, permanently curative surgery in the ulcer patient.

SUMMARY

1. Extensive duodenitis is suggested as the reason some patients cannot be controlled on a medical régime.

2. The ability of standard operations to relieve pylorospasm, hypermotility, hypersecretion and hyperacidity, which is the aim of medical treatment, is discussed. Resection alone completely fulfils these requirements.

3. Errors in technic and judgment are described, correction of which has reduced the mortality rate.

4. Resection for exclusion has given good results and is recommended for those patients in whom complete resection carries too great a risk. The prepyloric mucosa should be removed.

5. Antecolic anastomosis without jejunojejunostomy is the method of choice in the majority of cases.
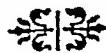
CONTINUOUS SPINAL ANESTHESIA*

REPORT OF ONE HUNDRED CASES IN WHICH THIS METHOD WAS EMPLOYED

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IN 1940, Dr. W. T. Lemmon, of Philadelphia, published his first work on spinal anesthesia by the continuous method. Research conducted on monkeys had shown him certain factors which he believed were true. The first of these factors was a new insight into the "fixation" of solutions. Lemmon demonstrated spinal anesthesia of a certain dose of one hour's duration in a monkey and then withdrawing the same amount of solution he had injected, he obtained the same length and degree of anesthesia in a second monkey after he had injected this dose into its subarachnoid space. He believed that only a small amount of the total injected solution in ordinary spinal anesthesia was being used and that the balance of this solution was not taken up by the nerves in the subarachnoid space until former fractions had been used up. The unused balance was idle until used and was subject to absorption by the circulation around the arachnoid which in turn produced the toxic effects often noted during "one injection" spinal anesthesia. He believed that a greater amount of the drug does not necessarily give a greater intensity of anesthesia, i.e., 500 mg. novocain does not give more intense anesthesia than 50 mg. over a given period of time.

The second factor was in the use of drugs. It is well known that the best drug for spinal anesthesia is novocain (ester of beta diethyl amino ethanol) based on its comparable low toxicity. Using toxicity of cocain as a standard of comparison (1) novocain is one-quarter as toxic, metycain three-quarters, pontocain three to five times more and nupercaine five times more

toxic. The only disadvantage of novocain was its short duration of action. Pontocain and nupercaine were used in spite of their greater toxicity because of their prolonged action. By the continuous spinal method the disadvantage of novocain's short action is overcome as well as the possibility of producing toxic effects by injecting a greater amount of solution than can be utilized by the nervous tissue in the arachnoid in a given length of time.

Lemmon believed that the preanesthetic medication of the patient was as important as the anesthetic itself. He states: "must premedicate sufficiently: it is malpractice to do otherwise." The usual procedure we employ based on the age, weight, and metabolic activity of the patient is as follows:

The adult patient of 150 pounds and normal metabolism is given 3 gr. of pentabarbital sodium the night before operation and this is repeated the following morning three hours before operation. No patient who is to have a spinal anesthesia should be denied a barbiturate unless there is a very definite contraindication, such as a known idiosyncrasy. One outstanding property of the barbiturate in this field is its protection against toxic reactions from anesthetic drugs. It diminishes the risk, suppressing the convulsions, and the interference with the respiration by the cocain series of drugs. One hour before operation ⅓ gr. of pantopon is given. Pantopon is used in place of morphine sulfate because the incidence of nausea and vomiting during anesthesia is less with this drug than with morphine. It has also been found that pantopon produces a greater narcosis than

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morphine. We combine scopolamine hydro-bromide (levo-scopine tropate) with this opiate in the proportion of 25 to 1. The combination of pantopon and scopolamine in ratio of one to twenty-five has its maximum action in one and one-half hours and lasts three to five hours when effects on circulation, respiration and analgesia are considered. The variable results following injections of scopolamine can be explained by the fact that the commercial product contains four alkaloids: (a) A laevorotatory alkaloid which has a sedative and amnesic effect; (b) a dextrorotatory alkaloid which has a stimulant or excitant effect; (c and d) two isomeric alkaloids with variable effects.

It is, therefore, most important to be certain in premedication that the scopolamine used contains the pure laevorotatory alkaloid alone. Scopolamine is preferred to atropine because of its cerebral depressing action especially when used with an opiate. Secretions are dried about equally as well. During the course of the operation opiates are given, with or without scopolamine if the nervous state of the patient demands it. These drugs may be given intramuscularly or, if quick action is desired, intravenously; and the injections are repeated if necessary to produce the proper somnolent state of the patient which should obtain during spinal anesthesia.

Lemmon has developed special needles and tubing for his method. A special mattress is also in use. This mattress has a gap in the side for the accommodation of the needle. The needles are made of a special alloy which allows great malleability. No stylettes are used with them, but they have an extra opening on the side of the bevel to compensate somewhat for this disadvantage. All punctures are done in the lateral prone position and the usual interspace chosen is between the lumbar third or fourth. However, the interspace chosen does not bear the same relation to height of anesthesia in this method as in ordinary spinal anesthesia methods because you may get the solution higher by repeated barbotage and by forceful injections.

One per cent novocain with $\frac{3}{4}$ gr. of ephedrine are used for a skin wheal. A spinawl is then used to puncture the skin and the muscles of the vertebral column because the malleability of the needles is such that they cannot perforate these heavy barriers without danger of extreme angulation. A No. 18 needle is generally used and inserted through the puncture wound made by the spinawl. On reaching the dura a greater sense of resistance is felt here because of the comparable dullness of the malleable needle. The needle should be held short to prevent bending on insertion through the skin. On puncturing the dura a 10 cc. Luer-Lock syringe is attached to the needle and 10 cc. of spinal fluid is withdrawn. The spinal fluid is then mixed with the novocain to make the desired solution concentration. A 5 per cent solution is generally employed for upper abdominal work, a 3 per cent solution for lower abdominal work and a 1 or 2 per cent solution for breast or intrathoracic work. If an additional quantity of solution is desired, it may be made up either with distilled water or with spinal fluid which may be withdrawn through the syringe and mixed with more novocain. After the solution is made to the desired percentage the syringe containing it is connected to two feet of rubber tubing with a narrow lumen which just holds 2 cc. of solution. After filling the lumen of the tube it is connected to the needle in the spine and slight barbotage is effected to determine if there is a free flow between the subarachnoid space and the syringe. If the flow is free, a fractional amount is injected into the subarachnoid space, the patient returned to the supine position and kept flat for abdominal work and in the Trendelenburg position for chest work. After return to the supine position the flow is checked again to determine if it is free; if not, the needle is given a half-turn in an effort to do so. The flow of fluid from the subarachnoid space to the syringe must be free for best results of this method and to insure control of the anesthesia which is another advantage of the

method. The height of anesthesia is determined in the usual way by skin testing and one may effect a higher level by barbotage. As the operation proceeds fractional doses are added as needed (usually in 50 mg. amounts). Degrees of anesthesia as well as length of anesthesia are thus obtained. Just enough anesthetic agent (novocain) is added to produce the desired depth of anesthesia. Anesthesia is produced within two to eight minutes depending upon the height of anesthesia desired. Spinal fluid is absorbed and reformed six to seven times in twenty-four hours; hence, the novocain injected is fairly rapidly removed from the subarachnoid space and frequent replenishment is indicated. It has been found that 70 per cent of novocain disappears from free fluid in five minutes and only traces are present after thirty minutes. A moderate loss of fluid (20 to 25 cc.) will be replaced in one hour. Phenosulfophthalein injected into the subarachnoid space has appeared in the urine in twenty-five minutes.

It is to be emphasized that the term, "continuous," is misleading. "Fractional spinal anesthesia" would be more accurate. The term, "continuous," is productive of a concept of a long period of time whereas this method is adaptable to the shortest procedures as well as the longest. It is an unquestioned procedure in other modalities of anesthesia (inhalation of ether, intravenous barbiturates, etc.) in giving just sufficient amounts of the drug and no more or less to produce the desired depth of anesthesia.

It is logical that the same procedure of fractional dosage should be used in spinal anesthesia and this method offers the

OPERATIONS DONE UNDER CONTINUOUS SPINAL
ANESTHESIA

Breast	1
Gastrointestinal	40
Biliary tract	15
Hernia	20
Gynecologic	15
Amputation..	5
Orthopedic ..	5
Genitourinary..	4
Total..	105

"modus operandi." In one of our cases a dose of 30 mg. of novocain was necessary for the surgical treatment of a fibroma of the leg which took a relatively short time to complete (twelve minutes). On the other hand, a radical breast amputation lasting three hours required 1,020 mg. of novocain.

CLASSIFICATION OF OPERATIONS

Radical Breast (1). The time during which the operation was performed lasted three hours and 1,020 mg. of novocain was used.

Gastrointestinal (40).

Abdominal perineal resections	5
Resection of cancer of colon and colostomy	3
Resection of cancer of cecum with lysis of adjacent adhesions	2
Intestinal exclusion with anastomosis of small intestines	2
Exploratory laparotomies	5
Appendectomies	20
Appendicitis with local peritonitis	3

The time during which the operation was performed lasted thirty-five minutes to three and one-half hours, using 75 to 430 mg. of novocain.

Biliary Tract (15). Exploratory Laparotomies (4).

Cancer of common duct with metastasis	2
Cancer of pancreas with metastasis	2

Cholecystectomies (11).

The time of operation was fifty minutes to two and one-half hours using 90 to 165 mg. of novocain.

Hernias (20).

Inguinal herniorrhaphies	8
Bilateral inguinal herniorrhaphies	7
Femoral herniorrhaphies	3
Scrotal herniorrhaphies	2

The time of operation was forty-five minutes to two hours using 75 to 165 mg. of novocain.

Gynecologic (15).

Pelvic	13
Vaginal	2

The time of operation was one to two hours using 99 to 160 mg. of novocain.

Amputations (5).

   Lower Extremity.................... 5

The time of operation was twenty-five minutes to one hour using 35 to 60 mg. of novocain.

Orthopedic (5).

   Bone graft, for nonunion............ 5

The time of operation was one and one-half to two and one-half hours using 100 to 185 mg. of novocain.

Genitourinary (4).

   Prostatectomy..................... 3
   Ureteral calculus.................. 1

The time of operation was thirty minutes to two hours using 60 to 150 mg. of novocain.

All the operations were begun and completed under continuous spinal anesthesia.

COMPLICATIONS

The drop in blood pressure under continuous spinal anesthesia was notably less than in other methods of spinal anesthesia. This probably is due to the relatively small amount of solution injected into the subarachnoid space at one time. The degree of blood pressure fall is generally directly proportional to the number of white rami anesthetized. The primary fall of blood pressure is caused by the progressive upward paralysis of the white rami, beginning at the third lumbar segment. It is negligible until a number of segments above this have been involved. Hence, the smaller amount of free solution in the subarachnoid space, the less amount is available to anesthetize the rami. Our practice has been to give $\frac{3}{4}$ gr. of ephedrine before anesthesia if the systolic blood pressure is below 150 mm. of mercury. If above 150 mm. of mercury, we give the spinal injection first and the ephedrine a few minutes later. In only 3 per cent of our cases was it necessary to give additional ephedrine. The average variation of blood pressure was between 25 to 50 mm. of mercury.

The criteria for wearing off of the anesthesia are: (1) Intestines are less contracted; (2) abdominal muscular tone is

regained; (3) patient complains of pain and discomfort; (4) a rise of blood pressure described by Dr. Lemmon as an indication of returning sensation was not constant in our series of cases.

If alarming toxic symptoms develop from injection of the novocain solution, one can with the fractional technic withdraw the cerebrospinal fluid (about 3 to 6 cc.) and it has been noted that the nerves recover promptly from the anesthesia. We have confirmed the above by withdrawing cerebrospinal fluid after operation in some of the cases while patients were unable to move their extremities under anesthesia and after withdrawal of cerebrospinal fluid the patients moved their extremities. Spinal anesthesia is maintained by the drug that is present in the cerebrospinal fluid; and when the concentration of the drug falls below a definite level, the analgesia promptly wears off.

In our series headache was an incident in only 2 per cent. The theory that postspinal anesthesia headache is due either to spinal leakage or meningeal irritation is pretty well refuted when it is considered that the needle is left *in situ* for as long as three hours. One of the most frequent questions asked is about the possible harmful effects of the needle remaining in place during the operation. The low incidence of headaches absolves the indwelling needle from producing spinal leakage and meningismus. The incidence of infection of the skin, muscles or meninges was nil in our series, although in one case fecal material had collected about the needle and remained there for two hours due to the spilling of intestinal contents through a colostomy under the surgical drapes.

In our series of cases, the incidence of urinary retention was 4 per cent. There were three instances of pulmonary atelectasis making an incidence of 3 per cent. There were no transient palsies or permanent paralysis. There were no vertebral arthritis. In making a survey of the literature for fatality incidence, due to single dose spinal anesthesia, we have found the

following: During the periods of 1929 to 1936 there were 39,146 spinal anesthesias administered with 486 deaths or a fatality incidence of 2.2 per cent. Observations based on an experience of 13,136 spinal anesthesias carried out by the anesthetic staff of Toronto General Hospital during the periods 1930 to 1939, analysis reveals a death rate of 1 per cent. In a large series of 15,652 administrations of spinal anesthesia in eighteen American hospitals, the immediate mortality (on the table) was 40 or about 1:500. Although the report in the literature presents such a wide variation in fatality incidence, we believe that the fractional technic of spinal anesthesia is the answer to the above disadvantage and problem of spinal anesthesia.

SUMMARY AND CONCLUSIONS

A method of spinal anesthesia is presented which is considered to have definite advantages over "single dose" spinal anesthesia. The advantages are: (a) fractional injections; (b) controllability; (c) decreased toxicity; and (d) regulated duration of analgesia.

REFERENCES

LEMMON, WILLIAM T. Continuous spinal anesthesia. Ann. Surg., January, 1940.

LEMMON, WILLIAM T. and PASCHAL, GEORGE W., JR. Continuous spinal anesthesia. Pennsylvania M. J., May, 1941.

HAND, LEO and SISI, L. F. Anesthesia for gastric surgery. Surg. Clin. North America, June, 1941.

HEWER, C. L. Recent Advances in Anesthesia and Analgesia. 3d ed. Philadelphia, 1937. P. Blakiston's Sons & Co.

CUNNINGHAM, HUGH A. Anesthesia. Marquette M. Rev., June, 1940.

MAXSON, L. H. Spinal Anesthesia. Philadelphia, 1938. J. B. Lippincott Co.

ADRIANI, JOHN. The Pharmacology of Anesthetic Drugs, Springfield, Ill., 1940. Charles C. Thomas.

BABCOCK, W. W. Spinal Anesthesia. Cyclopedia of Medicine. Philadelphia, 1939. F. A. Davis Co.

ROVENSTINE, E. A. The preparation of patient for anesthesia. J. Med., 1941.

BABCOCK, W. W. Survey of Spinal Anesthesia Deaths. Cyclopedia of Medicine. Philadelphia, 1939. F. A. Davis Co.

RANSON, S. W. Anatomy of the Nervous System. Philadelphia, 1923. W. B. Saunders Co.

DOGLIOTTI, A. M. Anesthesia. Chicago, 1939. S. B. Debour.

LABAT, GASTON. Regional Anesthesia. Its Technique and Clinical Application. Philadelphia, 1928. W. B. Saunders Co.

HOWELL, THOMAS F. and ROBERTSON, JARRETT P. Spinal Anesthesia. Am. J. Surg., 24: 120-133, 1934.

SILLIMAN, PRISCILLA. Nausea and vomiting during spinal anesthesia. Anesthesiology, 2: 333-338, 1941.

SUPRAPUBIC TROCAR DRAINAGE OF THE BLADDER*

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COMPLETE or partial retention of urine in man is a frequent complication of benign hyperplasia and of carcinoma of the prostate. In these patients the ultimate goal of therapy is, of course, the eventual removal of the obstructing prostate gland. However, the presence of urinary retention, whether acute or chronic, generally necessitates a preliminary period of treatment during which efforts must be directed principally toward (1) adequate drainage of the distended bladder, and (2) the prevention or control of infection of the urinary tract. A review of a group of patients who entered the Peter Bent Brigham Hospital with prostatic disease and urinary retention served to emphasize certain fundamental facts regarding these problems. As would be suspected, because of the age and poor general condition of the patients for whom suprapubic cystotomy was necessary, the morbidity and mortality in this group was higher than that in the group of prostatic patients in whom only drainage by catheter was needed. Yet a study of this latter group revealed that preoperative and postoperative complications of the urogenital tract were not infrequent, were often of a serious nature and occasionally terminated in death. This was particularly true in cases in which the constant indwelling catheter had been employed. After making a more detailed review of patients in this group who had such complications, it was evident that in all cases in which the outcome was unfavorable, there was only one constant finding, namely, every patient ran a septic course due to urinary infection, and in every instance this was apparently inaugurated or at least aggravated by some form of urethral instrumentation.

Although the use of the urethral catheter has been recognized as an indispensable means of treatment in many cases of obstruction of the bladder neck it has long been believed that it is not the ideal form of drainage. It is now known that the normal male urethra harbors certain bacterial organisms, principally the micrococcus and alpha streptococcus. As a result of the presence of a catheter in the urethra, with its attendant trauma, the growth of these organisms may be so promoted that there is initiated an active inflammatory process which may involve not only the urethra but also the bladder, and even one or both kidneys. Moreover, should a urinary infection exist before instrumentation, the employment of intermittent or continuous catheterization may serve only to intensify it. Any such infection is a grave detriment to the satisfactory progress of these patients, particularly so when it occurs in individuals of an age group frequently suffering from generalized arteriosclerosis, myocardial disease, hypertension, diabetes, etc. Its control, even with the use of the newer chemotherapeutic agents, may be extremely difficult. There are other drawbacks to the use of the urethral catheter which often contraindicate its employment. The channel of the urethra may be so distorted by the obstructing prostate that a catheter cannot be introduced through it into the bladder; or once introduced, its presence may be intolerable. Also, in occasional instances, drainage by this means may be incomplete and inadequate.

Recognizing the premise that the best surgical care of these patients is dependent upon prevention and elimination of infec-

bowel. It has been said that even with complete distention of the bladder, the depth to which the peritoneal fold descends
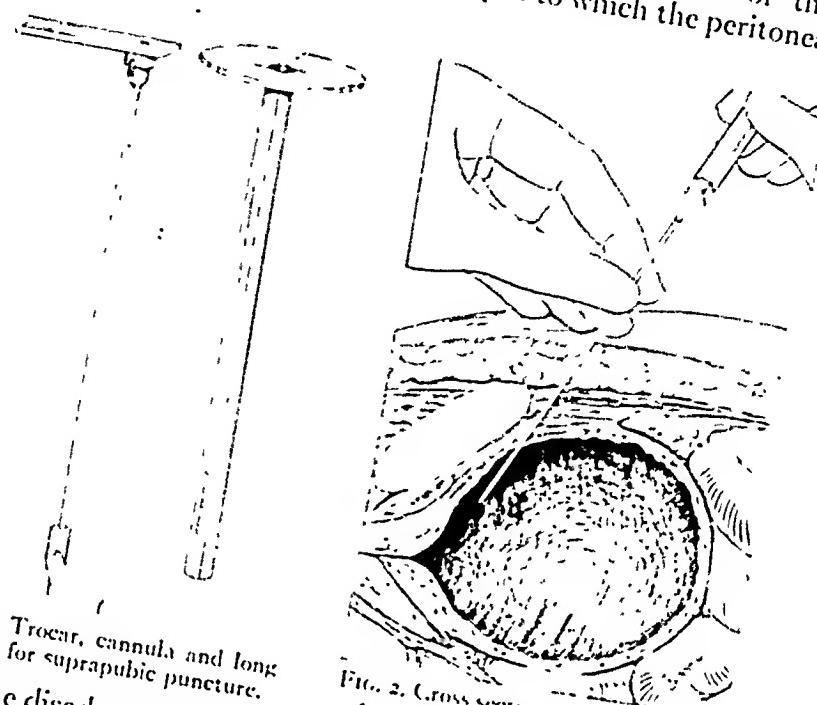
FIG. 1. Trocar, cannula and long needle for suprapubic puncture.
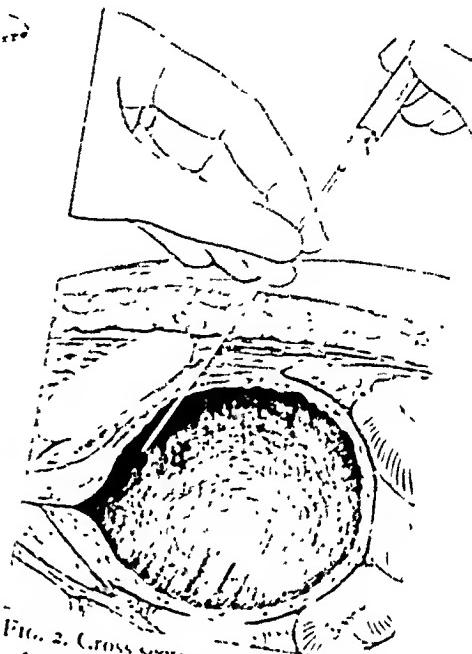
FIG. 2. Cross section of pelvis to illustrate direction of insertion of needle and manner in which trocar and cannula are threaded over needle after its entrance into the bladder.

tion, and aware of the disadvantages of the urethral catheter, it seemed that some method of drainage other than the urethral catheter should be instituted for the majority of patients preliminary to operation. Since open suprapubic cystotomy was thought to be definitely undesirable for routine use, we have adopted still another means of drainage which, in our hands, has been found more satisfactory than either the inlying catheter or suprapubic cystotomy. This consists of suprapubic puncture of the bladder by trocar and cannula through the prevesical space. An analysis of thirty-two consecutive cases in which the patients were so treated during the past two years is presented in this paper.

Suprapubic puncture of the bladder using a trocar and catheter has been employed occasionally for many years, but in the hands of those unaccustomed to the procedure it has been used with some hesitancy because of the assumed danger of perforating the peritoneum or a loop of

with relation to the symphysis pubis, is so variable as to make such puncture of the bladder unsafe. In the past two years, however, we have carried out this procedure many times, and as long as the bladder is tensely filled and palpable above the symphysis, we are certain of its safety and efficacy. It is a procedure which can be carried out in a few minutes, and with adequate premedication is attended by little pain. If the bladder is not palpable above the symphysis, a urethral catheter should first be introduced and the bladder filled to capacity before the trocar is used.

Various types of trocars, as found in the usual surgical armamentarium, are applicable for suprapubic puncture. The majority of these are of a size which will admit only a No. 14 to No. 16 French soft rubber catheter. The instrument which we have more commonly used, because of its slightly larger calibre and added safety,

is the one devised by Kreutzmann.* This consists of a special needle No. 22 wire gauge and the usual trocar and cannula, the latter (No. 22 French) sufficient to admit a No. 18 French catheter. (Fig. 1.)

TECHNIC OF PUNCTURE

The technic of suprapubic puncture by this instrument is as follows: The suprapubic region is sterilized as for a cystotomy. Under local infiltration anesthesia, a small vertical incision, ½ to 1 cm. in length, is made through the skin and fascia in the midline just above the symphysis pubis. The long needle is plunged inward and downward through this opening, passing just above and behind the symphysis. (Fig. 2.) When the bladder is entered, urine immediately trickles out of the needle. Should the intestine be perforated, gas will escape from the needle, but the very small puncture wound so caused is not sufficient to produce leakage and peritonitis. The trocar and cannula are then passed over the needle, and with slight rotary pressure the entire instrument enters the bladder guided by the needle. The trocar and needle are then removed, and a No. 18 French soft rubber graduated catheter is immediately passed through the cannula into the bladder. The cannula is then withdrawn, leaving the catheter in place. (Fig. 3.) A single silk suture passing through the skin edge and the wall of the catheter fixes the latter securely in place. A sterile dressing is applied and the catheter is connected to a sterile drainage system. Drainage is best when the tip of the catheter in the bladder lies approximately 12 cm. from the skin surface. At this level, cystoscopic examination shows the intravesical end of the tube to be above the bladder outlet and just resting on the trigone when the bladder is slightly or moderately distended. Drainage is also improved by cutting several extra holes at the intravesical end of the catheter.

* Kreutzmann, H. A. R. An improved suprapubic trocar and cannula. *J. Urol.*, 40: 341, 1938.

In the present series of thirty-two patients, twenty-nine had benign hyperplasia of the prostate, while in three instances the prostate contained carcinoma. Of the former group, twenty-two were free of other serious genitourinary tract complications, while one had an acute prostatitis, two had urethral stricture, two had acute and chronic pyelonephritis, one had a carcinoma of the rectosigmoid with local metastases and one had several vesical calculi. Of the three patients showing prostatic malignancy, one had no demonstrable metastases but moderately advanced local extension of the growth, while the other two had roentgenographic evidence of metastasis to the spine and pelvis. The average age of the patients with benign hypertrophy was sixty-seven years and of those with carcinoma sixty-four years. The average duration of symptoms in the former group was 4.7 years, and in the latter group 1.8 years.

Twenty-three patients entered the hospital with acute urinary retention, while nine patients had chronic retention of varying degree. (Table 1.) A number of the former group gave a history of chronic retention of variable duration preceding the attack of complete obstruction. In the majority of cases with acute retention, no definite causative factor preceding this event could be determined, but in others some form of urethral instrumentation, either for diagnostic or therapeutic purposes appeared to have initiated this outcome. In one instance, a diagnostic cystoscopy was followed by total obstruction and signs of an acute urinary infection which required hospitalization.

Of the entire group of thirty-two patients, there were twenty-seven upon whom some form of urethral instrumentation had been performed prior to admission to the hospital. A history of fever and chills preceding entry was obtained in ten patients; and in every instance the symptoms of infection were inaugurated by undue urethral trauma attendant upon attempted relief of obstruction or upon some otherwise

simple diagnostic procedure. Examination of these patients showed pus and bacteria in the urine. Cultures from the urethra were
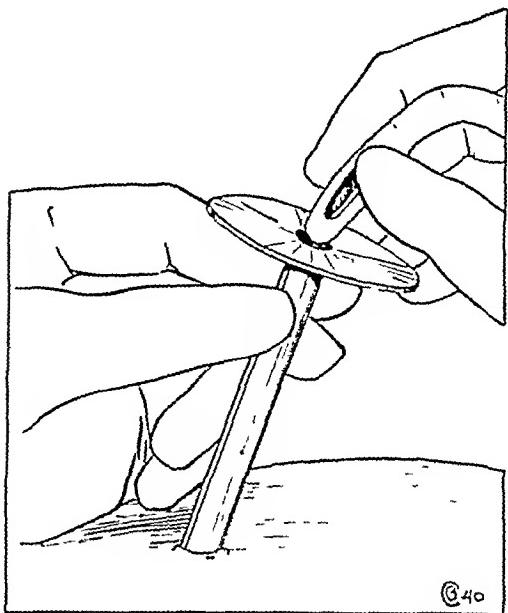
FIG. 3. Cannula in bladder and trocar removed, soft rubber catheter passed through cannula into bladder.

taken in many of these cases, and in approximately 40 per cent the organisms grown from the urethra and bladder were identical. It is of further interest to note that of the entire group, only four patients had a sterile bladder, and these were patients upon whom previous instrumentation had not been performed. This fact emphasizes the danger attendant upon urethral instrumentation of any patient having acute or chronic urinary retention.

In the majority of the cases, suprapubic trocar drainage was instituted soon after admission to the hospital and before any further urethral catheterizations were attempted. During the early part of this study, however, this form of procedure was not always followed; thus in five cases drainage was first obtained either by intermittent or constant urethral catheterization. But in every case trocar drainage was later instituted: in two instances because of the development of an acute urethritis, in one because of a rising fever and signs of acute urinary infection, in another because

of intolerance to the inlying catheter, and in the fifth case because a prolonged period of preoperative drainage was necessary and the patient was considered too poor a risk even for open suprapubic cystotomy. Bilateral vasectomy was usually done at the time of trocar drainage or during the period of drainage prior to operation.

Excluding the three patients with malignant disease of the prostate, all of whom were inoperable from the standpoint of a possible cure, there were in the remaining group of twenty-nine patients three poor risk cases. These were elderly patients who entered the hospital in a moribund condition, two in a state of coma, and all three showing signs of moderate or marked cardiac failure. In each case repeated urethral instrumentation had been carried out before admission to the hospital and on entry there was evidence of extensive urinary tract infection. Immediate suprapubic trocar puncture was performed and adequate drainage obtained. However, one patient died soon after entry with signs of cardiac and renal failure, while the other two, although improving sufficiently to undergo transurethral resection, died of bronchopneumonia and cardiac failure following operation. Death in each instance was due to factors not attributable to urinary sepsis or lack of adequate drainage.

Excluding these three patients who were poor risks, but including the three patients with malignant disease, there remain for study twenty-nine cases. In this group there were no preoperative deaths. The morbidity rate was correspondingly low and represents a distinct improvement as compared to that in a preceding series of patients with obstructing prostates who were drained with the urethral catheter. Following the trocar puncture and insertion of a catheter, there generally occurred a slight rise in temperature to 99° or 100°F. for twenty-four to forty-eight hours, following which the temperature returned to normal and remained so thereafter. Many patients showed no febrile reaction at all

after this procedure, while several others had a somewhat sharper elevation of temperature than usual to 101° or 102°F., urethritis or prostatitis. In contrast to the rather frequent occurrence of epididymitis which is seen during the course

TABLE I

	No. of Cases	Average Age, Yrs.	Average Duration of Symptoms, Yrs.	Retention		Previous Instrumentation		Blood Nonprotein Nitrogen			
								Before Trocar		After Trocar	
				Acute	Chronic	Yes	No	Elevated	Normal	Elevated	Normal
Benign hypertrophy.........	29	67	4.7	20	9	25	4	12	17	3*	26
Carcinoma................	3	64	1.8	3	0	2	1	1	2	0	3

* In 2 cases, NPN dropped from above 150 mg. per 100 cc. before drainage to 50–75 mg. per 100 cc. after drainage, at which range it remained constant. In 3rd case, NPN rose progressively above 120 mg. per 100 cc. and patient died of cardiac and renal failure on the third day after drainage.

TABLE II

	Urinary Infection on Entry		Diminution in No. of Pus Cells in Urine after Trocar		Urine Culture before Trocar			Urine Culture after Trocar		
	Yes	No	Yes	No	Pos.	Neg.	Not Taken	Pos.	Neg.	Not Taken
Benign hypertrophy..	+ 12 ++ 7 +++ 6	4	21	8	14	3	12	15	1	13
Carcinoma.............	+ 2 ++ 1 +++ 0	0	3	0	1	..	2	2	..	1

but in such instances a normal level was again reached within three to four days. Of the group of patients who entered the hospital with a history of preceding fever and chills following urethral instrumentation, several of whom had been on inlying catheter drainage for varying periods of time, all showed a surprisingly prompt return of the temperature to normal after the institution of suprapubic trocar drainage. There was almost complete relief of bladder symptoms in all except a few, and these became asymptomatic following proper adjustment of the catheter or after local treatment of a previously existing

of preoperative drainage by urethral catheter, it is noteworthy that this complication was not observed in the present series of cases.

As will be seen from Table II, there was relatively little change in the bacteriological characteristics of the urine after suprapubic trocar drainage. Those patients who showed a growth of organisms in the urine before this form of drainage was instituted continued to do so after drainage but to a less marked degree. The number of pus cells, however, was definitely diminished in over 70 per cent of the cases, and in the majority of those whose urine re-

mained unchanged, some focus of infection elsewhere in the urinary tract, usually the kidney, was accountable for the persistent pyuria. On the whole, the urine of patients drained in this manner remained clearer than that of patients who had had urethral catheter drainage; and in contrast to the marked cystitis so often observed in the latter group, the bladders in these patients were relatively free of inflammation. There was generally some infection and bullous edema on the floor of the bladder where the tip of the catheter rested, but the mucosa elsewhere was quite clear.

The duration of preoperative drainage varied between six and twenty days, the minimum being two days; the maximum being one hundred thirty-five days. In those instances in which prolonged drainage was necessary, no difficulty was encountered in changing the catheter whenever deemed advisable, since a well formed sinus tract had usually been established by the end of two weeks. No serious complications attributable to suprapubic puncture drainage were observed during the course of this study, although there were several minor complications of interest. These were the result of inexpert use of the trocar, for in each instance the puncture was carried out by a junior intern who was performing this procedure for the first time and had difficulty with the proper insertion of the trocar; this undoubtedly caused considerable trauma to the perivesical tissues. One patient developed a prevesical abscess on the tenth day of drainage for which suprapubic cystotomy and drainage of the abscess were performed, later followed by an uneventful suprapubic prostatectomy. Another patient had a chill and abrupt elevation of temperature four hours after suprapubic puncture and within twelve hours developed marked lower abdominal pain, tenderness and muscle spasm. Although drainage of urine appeared to be adequate, it was believed that possible perforation of the peritoneum might have occurred, and accordingly, open cystotomy was done. At operation no tear in the peritoneum or bowel was found; the perivesical tissues appeared normal. The patient's symptoms and signs subsided immediately after the institution of open drainage. He later underwent prostatic enucleation without event and made a good recovery.

Prostatectomy, either enucleation or resection, was performed in all except two of the thirty-two cases. One man with advanced carcinoma of the prostate, who entered the hospital because of acute retention, was discharged without operation and died several weeks later of malignancy. A second man, previously mentioned, died of uremia and cardiac failure on the fourth day after the establishment of trocar drainage. In the remaining group of thirty patients, there were two deaths following operation, both occurring in patients who were bad risks. The operative mortality for the entire series was thus 6.6 per cent; while if the poor risk patients are eliminated, the operative mortality was 0 per cent. In the majority of cases, convalescence following operation was quite smooth and complications were infrequent. Bilateral epididymitis occurred in two instances, moderate urethritis in four instances following perineal prostatectomy, and prostatic bed infection in two instances following transurethral resection.

Follow-up studies were obtained in nineteen of the thirty-two cases. There were twelve patients who showed a clear, sterile urine within three to six months after discharge from the hospital. The urine in four others still contained a few leucocytes at the end of this time, but cultures of the urine were negative in two of this group. Two patients who had chronic pyelonephritis still showed a moderate pyuria two and four months after operation, respectively, while one man was readmitted to the hospital six weeks after operation having a staphylococcus bacteremia which terminated in death. The urine in this case contained many pus cells and showed a heavy growth of Bacillus coli and Staphylococcus aureus on culture

In all patients whom we were able to examine postoperatively, there remained little or no evidence of residual obstruction at the bladder neck. The suprapubic puncture wounds, which had closed within six to twelve hours after removal of the catheter, were well healed and without signs of infection.

Since adopting the use of suprapubic trocar drainage for the preoperative preparation of a majority of our patients with obstructing prostates, we have also carried out this procedure in instances of acute and chronic urinary retention due to other causes, particularly in certain cases in which urethral instrumentation is contraindicated due to adjacent infection. It has been performed once for retention due to a prostatic abscess, twice for obstruction due to impermeable urethral strictures and once for chronic retention in a patient with a cord bladder. In each instance the subsequent course of the patient has confirmed the efficacy of this method of treatment, signs of infection rapidly subsiding and no complications occurring during the following period of local therapy.

SUMMARY

A review of our cases of urinary obstruction due to prostatism, in which urethral catheter drainage had been used as a means of preliminary preparation for operation, revealed that the preoperative morbidity and mortality in patients who were otherwise good risks was relatively high, and that complications were not infrequent. Further study of this group showed that these undesirable occurrences were directly attributable to urinary sepsis, and that in every instance this was introduced or accentuated by some form of urethral instrumentation. For this reason we believed that a method of drainage other than the urethral catheter should be used, and therefore in the past two years we have substituted suprapubic trocar drainage for such patients.

A series of thirty-two cases of patients with urinary retention due to benign hypertrophy and carcinoma of the prostate treated in this manner has been reviewed, and the results of this study analyzed.

By this method of preoperative preparation, the routine care of patients with obstruction of the bladder outlet is greatly facilitated, the urinary tract infection which accompanies urethral drainage is largely eliminated, excellent decompression of the bladder can be maintained without the subjective discomfort so often attendant upon an inlying urethral catheter and complications are infrequent.

As a result of our experience, we believe that suprapubic trocar drainage of the bladder is an entirely safe procedure, and that its use in acute and chronic urinary retention due to prostatic obstruction has substantially reduced the preoperative and postoperative morbidity and mortality of this disease.

PROCTOLOGY IN GENERAL OFFICE PRACTICE

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THE extent to which the general practitioner may attempt to treat proctologic disorders will depend on his surgical training, ability, aptitude and knowledge. Dexterity in the use of the simple proctologic armamentarium and a knowledge of the correct interpretation of the various findings are essential; these can only be gained from actual experience.

Inspection of the perineum and circumanal area reveals the presence or absence of external hemorrhoids, tabs, anal fissures or ulcers, perianal cutaneous changes and discharges from the anal orifice. Digital examination elicits spasm of the anal sphincter muscles, tenderness, induration and neoplasm. Bidigital examination (the index finger in the anal canal and thumb on the perianal area) will frequently localize tender areas and give a clue to hidden suppurations in the perianal tissues. Every patient with anorectal complaints or disease should have a sigmoidoscopic examination. This examination is especially important in the visualization of the ampulla for here roentgenologic examination is unreliable. Anoproctosigmoidoscopic examination is best performed in the inverted position; it may, however, be carried out successfully in other positions, such as in the Sims. In this examination the terminal 25 cm. of the bowel can be directly visualized and material for microscopic study may be obtained. The roentgenologic examination of the colon with the aid of barium sulfate should be carried out in every case with a questionable diagnosis or where concomitant disease of the colon is suspected.

The discharges from the anal orifice should be stained with Gram and Ziehl-Neelsen stains. The stool may be examined in the office for ova, cysts, parasites and occult blood. In suspected cases scrapings of the mucosa or from the surface of an ulcer should be adequately studied for amebae and cysts; these scrapings also constitute good material for culture of enteric organisms. Neoplasms (and ulcers on occasion) should be biopsied.

RECTAL BLEEDING

Rectal bleeding is a common but most neglected complaint and calls for a systematic and thorough examination. Internal hemorrhoids are the most frequent cause while neoplasm is the most important. Rarely, bleeding in children may originate from an ulceration of aberrant gastric mucosa in the rectum.[1] Blood dyscrasias and vitamin C and K deficiencies may cause occult or gross bleeding from the colon and rectum. Bleeding noted in diarrheas is frequently an expression of subclinical hypovitaminosis.[2]

PRURITUS ANI

The etiology and the treatment of this condition are still poorly understood; a comprehensive study requiring the services of several specialists is at times necessary. Rigid cleanliness is very essential. Lilienthal's method of applying bland ointments to the perianal region prior to defecation prevents fecal soiling and is effective in many cases.[3] For topical application, gentian violet dissolved in water or alcohol and Castellani's carbolfuchsin solution with or without menthol appear to be the most effective drugs. The injection of the oil soluble long acting anesthetics into the perianal tissues has resulted in a permanent cure in a few and in temporary relief in many cases. Concomitant anorectal lesions should be extirpated in all cases of pruritus ani regardless of their etiologic importance in pruritus. The intractable cases of pruritus ani may be treated by the perianal

injection of alcohol or by the tattooing of the anal canal and the perianal region with mercury sulfide. To date, tattooing with mercury sulfide has yielded most encouraging results.[4]

HEMORRHOIDS

Perianal hematomas (thrombosed external piles) may be treated conservatively with external heat, or by operation, if pain continues in spite of conservative treatment. Mixed (internal and external) piles should be removed surgically. The operation of choice is a nontraumatizing procedure that will remove the varices as well as the sources and channels of infection and provide ample drainage through the open wounds. The incisions are made in the long axis to the rectum and anal tube and are carried to the perianal skin in a radial manner. Strangulated internal piles are treated either by immediate operation or by palliative measures and deferred surgery. The author prefers immediate operation combined with the administration of sulfonamides.

Uncomplicated, soft, bleeding, prolapsing and spontaneously reducible internal hemorrhoids are suitable for injectional therapy. The main purpose of this form of treatment is to stop bleeding and to correct the associated prolapse. Recurrences are dependent on the fate of the fibrosis produced and on the elimination of the etiologic factors which had existed prior to the institution of injectional therapy. The contraindications to injection treatment include the presence of mixed piles, recent or old inflammation or infection, neoplastic disease in the anorectocolonic tube or other concomitant local lesions requiring surgical treatment. The technics of injection vary with the experience of the operator. I prefer to make weekly submucous injections about the pedicle of the hemorrhoid above the anorectal ring thus obliterating the hemorrhoidal vein of each internal pile and fixing the mucosa at a high level to prevent prolapse. Subsequently, weekly injections are made into the hemorrhoidal masses at a lower level. I usually employ a 5 per cent solution of quinine and urea hydrochloride. (Recently, I have been studying the efficacy and effects of sodium psylliate.) The injectional method of treatment is neither simple nor without danger; it has definite limitations which should be understood lest disappointments and complications result.

ANAL FISSURES (ULCERS)

The acute fissure is superficial and without adjacent inflammation or induration. It either heals spontaneously or by the topical application of bland ointments. Occasionally, the long acting soluble anesthetics are used to allay pain.

The chronic fissure is an ulcer with adjacent induration and inflammation and is accompanied by dysfunction and fibrosis of the subcutaneous portion of the external anal sphincter muscle. This lesion is best treated by wide excision of the ulcer bearing area including the involved crypt or crypts (and the sentinel pile, if present) followed by the division of the subcutaneous component of the external anal sphincter muscle. The use of the long acting oil soluble anesthetics for the treatment of this lesion is dangerous and ineffective. The operation is effective and safe and is preferable to the taking of even the slightest risk with the injection of the slow absorbing anesthetic solution.[5]

ANAL ABSCESS AND ANAL FISTULA

Perianal abscess usually originates in an infection of a crypt of Morgagni and anal ducts and may eventually result in an anal fistula. The anal ducts empty into the crypts but lead to racemose anal glands situated in the perianal tissues and may pierce the anal sphincter muscles. Anal and perianal abscesses should be incised and drained adequately at the earliest opportunity. For the radical cure of fistula-in-ano, the entire tract and the surrounding infected granulation tissue should be excised followed by light packing of the wound with plain or iodoform gauze.

Of equal importance is the correct and meticulous postoperative care. Anal incontinence may follow an incorrectly performed fistulectomy; it is almost always a "product of unforgivable incompetence."[6]

POLYPS

Small islets of hyperplasia of the epithelium of the rectum and sigmoid are believed to be precursors of polyps.[7] The great clinical significance of polypoid disease lies in its frequency of progression to malignancy. Occasionally, polyps associated with ulcerative colitis may undergo adenomatous or malignant changes.[8] Polyps and the islets of hyperplasia are best destroyed by fulguration. This procedure is not without risk even in the hands of the experts. Polyps occurring below the reflection of the peritoneum may be treated in the office; those occurring above the peritoneal reflection should be treated in a hospital. Polyps of the colon situated beyond the safe reach of the sigmoidoscope should be extirpated through a transcolonic procedure.[9]

STRICTURE

Benign rectal strictures are either of traumatic, operative or inflammatory origin. The last type is most frequently produced by venereal lymphogranuloma. These rectal strictures may be diaphragmatic or tubular in character. Strictures and other rectal complications (proctitis, suppurations, fistula-in-ano, etc.) are the result of the spread of the virus from the genital tract to the pararectal glands producing perirectal infection and fibrosis. A positive intracutaneous Frei test usually establishes the diagnosis of venereal lymphogranuloma. However, the isolation of the virus in the bowel discharges or tissues constitutes positive proof that the virus is the cause of the intestinal lesion. The sulfonamides or Frei antigen are effective therapeutic agents exerting beneficial systemic and local effects.[10,11] Since the institution of chemotherapy, surgical treatment of the anorectocolonic manifestations of venereal lymphogranuloma has been largely limited to incision and drainage of localized perianal and perirectal suppurations, to the performance of an occasional temporary colostomy for acute obstruction and to the digital or instrumental dilatation of the fibrous stricture.

ANAL GONORRHEA

It is known that gonococci may remain alive and virulent for years in the anal structures and that reinfection of the genital tract may result from the anal focus. Suitable biologic conditions for the acquisition and maintenance of gonorrheal infection are furnished by the transitional epithelium of the intermediate zone of the anal canal, the anal ducts and the crypts of Morgagni. Sulfanilamide or its derivatives administered orally is effective against anal gonorrhea in the absence of localized suppurations or poorly draining sinuses.[12]

ANORECTAL TUBERCULOSIS

In many cases a diagnosis of anorectal tuberculosis can be made clinically by the characteristic appearance of the anal lesions. The presence of tuberculosis in the anorectal granulation tissues on histologic examination is an essential criterion for the diagnosis of a tuberculous anal lesion in the patient with pulmonary tuberculosis who has a positive sputum.[13] These patients may harbor viable and virulent tubercle bacilli in the terminal bowel, hence the finding of the tubercle bacillus by culture or animal inoculation is not significant in the study of their anal lesions. In contrast, the cultures and animal inoculation are conclusive in the study of anorectal lesions of patients with pulmonary tuberculosis who have negative sputa. The cure of the tuberculous anorectal lesion demands radical surgical extirpation and meticulous postoperative care. Healing is complete following proper surgical therapy that is augmented by measures aiming to improve the general health of the patient.

PEDIATRIC PROCTOLOGY

The indications for proctosigmoidoscopic examination of infants and children are the same as those for adults. Juveniles, like adults, are subject to inflammatory bacterial or parasitic disease, suppurations, fistulas and fissure-in-ano, prolapse of the rectum, benign and malignant polyps and other tumors. Unlike adults, infants and young children seldom have internal piles but more often show congenital malformations of the anus and rectum.

AMBULATORY OPERATIVE TREATMENT

Perianal hematoma (external thrombosed pile), subacute fissures and short subcutaneous sinuses or fistulas are suitable for ambulatory operative treatment.[14] Those performing ambulatory operations for anorectal lesions must provide office facilities for immediate postoperative rest and care, and proper supervision at the patient's home. It is generally admitted that ambulatory surgical treatment of anorectal disorders is usually incomplete in scope and only palliative in character. It can hardly be gainsaid that better results follow operations performed in a hospital.[15]

SUMMARY

Salient features of diagnosis and treatment of anorectal diseases are briefly presented to serve as a guide to those who do not specialize in proctology. Established principles and procedures are re-emphasized and new and important facts, such as chemotherapy for anorectal manifestations of venereal lymphogranuloma and uncomplicated anal gonorrhea, and tattooing of the anal and perianal areas with mercury sulfide for intractable pernicious pruritus ani, are discussed.

REFERENCES

1. FLEET, G. A. Misplaced gastric mucosa as a cause of massive rectal hemorrhage. *Canad. M. A. J.*, 42: 216, 1940.
2. MACKIE, T. T. Vitamin deficiencies in gastrointestinal disease. *Ann. Int. Med.*, 14: 28, 1940.
3. LILIENTHAL, H. Pruritus ani. *J. A. M. A.*, 110: 509, 1938.
4. TURELL, R. Tattooing (puncturation) with mercury sulfide and other chemicals for treatment of pruritus ani and perinei: further investigations. *J. Invest. Dermat.*, 3: 289, 1940.
5. WASS, S. H. Painful affections of anal canal. *Guy's Hosp. Gaz.*, 54: 110, 1940.
6. BLAISDELL, P. C. Pathogenesis of anal fissure and implications as to treatment. *Surg., Gynec. & Obst.*, 65: 672, 1937.
7. MARTIN, W. J., JR. Polypoid versus carcinomatous lesions of colon and rectum. *South. M. J.*, 33: 428, 1940.
8. COFFEY, R. J. and BARGEN, J. A. Intestinal polyps: pathogenesis and relation to malignancy. *Surg., Gynec. & Obst.*, 69: 136, 1939.
9. CATTELL, R. B. and SWINTON, N. W. Diagnosis and treatment of sigmoidal polyps. *New England J. Med.*, 222: 535, 1940.
10. MARINO, A. W. M., TURELL, R., BUDA, A. M. and NERB, L. Treatment of venereal lymphogranuloma with sulfanilamide. *Am. J. Surg.*, 46: 343, 1939.
11. KORNBLITH, B. A. Lymphogranuloma venereum. *Am. J. M. Sc.*, 198: 231, 1939.
12. TURELL, R. Sulfanilamide in treatment of gonorrhea of anal canal. *J. Lab. & Clin. Med.*, in press.
13. MARTIN, C. L. and SWEANY, H. C. Tuberculous anal abscess and fistula criteria for diagnosis. *Surg., Gynec. & Obst.*, 71: 294, 1940.
14. ANDERSON, J. K. Office treatment of rectal and anal pathology. *Nebraska M. J.*, 24: 441, 1939.
15. JEURINK, V. G. Office treatment of common rectal disorders. *Rocky Mountain M. J.*, 36: 629, 1939.
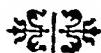
PERIPHERAL VASCULAR SURGERY*

LESSONS FROM SIX YEARS' EXPERIENCE

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THE present trend toward a reclassification of gangrene in the lower extremity is most timely. Because of the misleading implications of the older classification, this change will be welcomed by the clinician when confronted with the question of what and how much to do. The newer concept of the pathological processes involved and the tremendous improvement in our therapeutic measures for regulating the patient's metabolism have practically eliminated diabetes as an immediate factor in handling gangrene. The former division of necrotic lesions of the lower extremity into diabetic and arteriosclerotic has, therefore, lost its significance and has become more confusing to the clinician than helpful.

The pathological problem presented in a lesion of a toe or a foot resolves itself, as has frequently been emphasized, into one of inadequate arteriation, one of infection or a combination of both, with or without the metabolic derangement known as diabetes mellitus. The newer classification of these lesions into vascular, infectious or mixed is more to the point and much sounder because of its contribution toward a saner therapeutic approach. The classification heretofore employed, perhaps to impress the surgeon with the old adage of not to temporize with infection in a diabetic patient for fear of rapid spreading and not to deal conservatively with an extremity affected with necrosis in the presence of diabetes, because sooner or later the extremity has to come to major amputation, is not workable any more; and while a number of extremities with even little evidence of necrosis come

eventually to total amputation, the reason is not diabetes, but rather that many of these lesions are due to infection preying upon a limb devitalized by an already impoverished circulation whatever the primary cause.

When the use of insulin first became popular some fifteen years ago, a wave of conservatism and watchful waiting for developments in surgical lesions in diabetic patients came into vogue. The hope was that an attempt at controlling the metabolic status might rally enough of the patient's forces of resistance to arrest the spreading pathological process and effect a localization, making the lesion an easier target for surgical attack. The often resultant prolonged morbidity, however, sapping both the vitality and morale of the patient and resulting in a higher mortality of secondary and delayed primary operations, has caused a revolt against conservative surgery, and a swinging of the pendulum back toward the ultra-radical formula of necrosis in the lower extremity plus diabetes calls for midthigh amputation.

Today, through better appreciation of the underlying pathological process, the pendulum stands at a happier medium and until new pathological factors are uncovered, this stand is bound to vary little, if at all. A surgeon confronted with a necrotic lesion in an extremity has two major questions to ask before proceeding to formulate a course of therapy. The general condition of the patient is the surgeon's first concern, and once studied and adequately prescribed for, the surgeon

can turn to the local lesion for scrutiny and thorough investigation.

The first problem involved in the patient's general condition is that of his metabolic status. Is the patient afflicted or not with the syndrome called diabetes mellitus? A history might reveal symptoms or previous treatment, blood sugar, the extent of the derangement and of infection. A blood carbon dioxide combining power reveals the proximity of the patient to acidosis. A preliminary urine sugar acts as an index to evaluate the efficacy of therapy following its institution. Patients without diabetes may be designated as those without metabolic derangement, whereas diabetic patients are classified into three groups:

1. Untreated patients with fasting blood sugars of not more than 180 mg. or when treated are controlled by not more than fifteen daily units of protamine zinc insulin, are classified as suffering from mild metabolic derangement and are designated as +1 diabetic patients.

2. Patients with fasting blood sugars of not more than 300 mg. or when treated are controlled by not more than thirty-five units of protamine zinc insulin daily, are classified as cases with moderate metabolic derangement and are designated as +2 diabetic patients.

3. Patients with fasting blood sugars of more than 300 mg. or when treated require more than thirty-five daily units of protamine zinc insulin are those with marked metabolic derangement and are designated as +3 diabetic patients.

It must always be remembered that the atheromatous condition of the vessels to which much of the pathological condition in the extremity is due does not limit itself to the vessels of the extremity alone, but is usually present in the entire arterial tree. The vessels of the heart and kidneys are rarely spared. A history, therefore, of limitation of the patient's previous activity, previous heart attacks, or a story of effort syndrome may reveal coronary or myocardial impairment. A tracing might help to indicate how soon the patient can be put in a wheel chair after operation without turning pale or begin to perspire and collapse.

The vascular pathological process must have of necessity affected his kidneys to a greater or lesser extent. A low urine specific gravity and a high blood urea might demonstrate the degree of nephrosclerosis and indicate an adjustment in diet and fluid intake.

Once acquainted with the general condition of the patient and having prescribed for the various findings, the attention of the surgeon may be focused upon the local condition and here the investigation has to be more exhaustive.

The first concern is the status of the circulation of the involved extremity. The nutrition of the limb is investigated thoroughly by studying the two major circulations: (1) primary and (2) collateral.

A history of claudication, easy fatigue, pains upon walking, having to rest after a short stroll, night pains in the calves and legs, tingling, numbness, coldness of the extremity, slow growth of the nails, all this would help to appraise the extent of arterial starvation of the extremity. Inspection of the leg might reveal a near mummified condition with loose, dry skin, atrophy of fat and muscles, absence of hair, striation of nails, pallor of the extremity with or without elevation, and with or without exercise.

It must be remembered, nevertheless, that in the literature undue emphasis is laid upon the question of atrophy of the hair and transverse striation of the nails, for while they often are present in vascular lesions these phenomena are part of the senile changes that these organs undergo in the aged and might be marked, despite excellent arterial pulsations or adequate collateral circulation and are, therefore, not always indicative of vascular insufficiency.

Palpation of each of the dorsalis pedis artery, posterior tibial and femoral will reflect the condition of the primary circulation of the leg. Each of these vessels should

be palpated separately and no one vessel can substitute for the others. An extremity with a hardly palpable femoral artery might have a fair dorsalis pedis and vice versa, for at times the collateral network around an occluded vessel might have developed enough to allow for good pulsations farther down in the extremity. The popliteal is difficult to palpate even in a normal limb and cannot be relied upon Oscillometric readings of the extremity are taken and recorded on the special graph. Tracings are made of each extremity and are taken with the cuff of the oscillometer applied below the ankle, indicated with (BA), above the ankle (AA), below the knee, (BK) and above the knee, (AK).

Neither arterial palpation nor oscillometric readings can solely be relied upon to ascertain the circulatory status of an extremity, for while they give an idea as to the condition of the circulation in the main arteries of the leg, they do not indicate the extent of development of the collateral network. That the collateral circulation might be adequate despite non-pulsating arteries and oscillometric readings of zero is a fact that has been demonstrated time and again. The histamine flare and saline wheel are a disappointment and very misleading and the sole criterion of the circulation in the collateral tree is the history and inspection of the extremity itself.

William's and O'Kane's idea of classifying leg lesions into vascular, infectious or mixed is a helpful one. Their classifications could be greatly simplified, however, if their plus one, plus two, plus three and plus four impairments were changed into plus one for mild impairment, plus two for moderate impairment, and plus three for marked impairment of the circulation of the extremity. Under plus one vascular lesions are classified all lesions with diminished oscillations, but no history of arterial blood hunger and no evidence of atrophy or pallor. Under plus two are classified cases with nonpalpable dorsalis pedis or posterior tibial arteries, but in

which the collateral circulation has developed enough so that there is no history and very mild symptoms of arterial insufficiency, claudication, night pains, etc., and no evidence of atrophic changes in the extremity. Plus three cases are those in which the arterial oscillations are zero from below the knee down and with definite history of arterial starvation and evidence of atrophy in the leg. The following table which is a modification of William's and O'Kane's will help to clarify these points:

Symptoms	Plus One	Plus Two	Plus Three
Claudication	None	Mild—3 to 4 blocks	Marked half block or less
Night pains	None	None	Present
Coldness	None	At times	Common
Numbness	None	None	At times
Tingling	None	None	May be present
Signs			
Hair atrophy	May be present	May be present	Present
Muscle and fat atrophy	Absent	Slight	Marked
Striation of nails	May be present	May be present	Present
Femoral pulsations	Present	Diminished	Diminished or absent
Posterior tibial	Diminished	Absent	Absent
Dorsalis pedis	Faint	Absent	Absent
Oscillometric Readings			
Above knee (AK)	3 to 4	2 to 3	0 to 1
Below knee (BK)	2 to 3	1 to 2	0
Above ankle (AA)	1 to 2	0 to 1	0
Below ankle (BA)	0 to 1	0	0

Once the surgeon is satisfied with his evaluation of the circulatory status of the extremity, the virulence and extent of infection should be ascertained. The toxic condition of the patient, the febrile reaction, sweats and positive blood cultures aid in revealing the extent and severity of infection in addition to local edema, redness and tenderness. The amount of discharge plus a smear with x-rays for bony involvement complete the appraisal of existing infection.

It is helpful to classify infection under the same three headings used for vascular impairment: Under the plus one group would be classified mild infection, plus two moderate infections and plus three severe infections. The following table elucidates

the points upon which the classification is based:

Symptoms	Plus One	Plus Two	Plus Three
Pain .	Absent or mild	Present	Marked
Throbbing	Mild	Moderate or marked	Marked
Signs			
Redness .	Slight	Marked	Bronzing
Swelling ...	Slight	Moderate	Marked
Local heat	Slight	Moderate	Marked
Discharge .	None	Slight	Moderate or copious
Temperature	Normal	Up to 100 5	Over 100 5
Inguinal glands	None or slight	Present	Present
Blood culture	Negative	Negative	Negative or Positive
Smear and local culture	Staphylococci	Staphylococci Streptococci Bacillus coli	Streptococci Bacillus coli Bacillus welchii

The classification of infection is not as important as that of the vascular status inasmuch as the degree of infection may vary from day to day whereas vascular impairment hardly changes from one month to the other.

Once the patient's lesion is diagnosed and classified as vascular plus one, infectious plus three, diabetic plus two, (V+ I+++ D++), the surgeon is ready to chart his course of local therapy.

Purely vascular lesions, (plus two) and small (plus three) lesions are watched while treated conservatively. The following is the routine we have found most helpful: (1) Elevation of the head of the bed with one-foot blocks; (2) wrap the affected limb in cotton wool from groin to toe; (3) allow bathroom privileges; walking to bathroom will give patient all the advantages of Buerger's exercises; (4) intravenous salt solution in patients with blood pressure of not more than 185 systolic. Three hundred cc. of 5 per cent sodium chloride are given two to three times weekly. Too much saline is harmful. We have seen inflammation commence or extend rapidly once the extremities became edematous following daily saline infusions. It is a question whether saline helps the lesion proper or not, but the sense of warmth felt in the extremity is greatly appreciated by the

patient and pains are greatly diminished following the infusions. (5) Intravenous vitamin B complex seems helpful in certain cases. No other type of medication or injection has been helpful in our hands.

Physiotherapeutic measures have failed us completely. This includes suction pressure, intermittent venous occlusion, oscillating bed, diathermy, dry heat, etc. The successes with these methods reported in the literature may be due to the rest and better nutrition entailed in a hospital stay for the average charity case without these advantages at home. We have not been able to duplicate the reported results in well-to-do patients.

We have had no experience with posterior root or periarterial sympathectomies, but from cases done in other hospitals that occasionally come to amputation in our own, the value of these procedures seems questionable.

We have not attempted femoral or popliteal vein ligation recently, notwithstanding the plausibility of the rationale behind venous occlusion intermittent or otherwise. In actual practice it does not work.

Suppurating cavities are packed daily with 1:500 azochloramid in triacetin gauze. Discharging ulcers are treated with wet soaks, granulating ulcers with coagulents such as tannic acid when the area is small, or skin grafting for large defects. We use petrolatum jelly as a dressing for clean postoperative wounds, but we are disappointed in its use in ointment form whatever the combination. Repeatedly, we have seen freshly healed ulcers with delicate scars break down completely when ointments are applied over a small residual patch of ulceration.

Extensive vascular one or two with infectious plus two or plus three may occasionally be treated by a midcalf amputation. There is no place for a Syms or a Gritti-Stokes or even flap amputation through the lower third of the thigh.

Pure, or mixed vascular plus three lesions and extensive mixed vascular plus

two lesions are treated by amputation through the lower third of the thigh.

OPERATIVE TECHNIC

The technic employed is the following: With 60 mg. of procaine in 1.5 to 2 cc. of

suitably draped; the leg is then wrapped and bandaged neatly from the upper border of the patella down to the toes. The leg is held by an assistant while a towel is wrapped over the upper thigh about four-finger breadths above the bandage. A

FIG 1.

FIG 2

FIG 3

FIG 4

FIGS 1 to 4 For legend see opposite page

cerebrospinal fluid introduced in the third or fourth lumbar interspace, the leg is anesthetized. Formerly, we insisted upon a forty-eight-hour preparation, but the fallacy of this prolonged procedure soon became evident and it has since been reduced from forty-eight hours to ten minutes. Once anesthetized, for ten minutes the leg is first scrubbed from below the knee down to the inguinal and gluteal folds with benzine, then dried with a sterile towel. The leg is then scrubbed with green soap and water, dried and painted with 1.5 per cent tincture of iodine and washed with alcohol. The area around the thigh is

tourniquet is applied over the towel just as the surgeon is ready for his incision. The tourniquet is applied high on the thigh to avoid inversion of the edge of the stump following section.

A circular incision is made with an amputation knife two-finger breadths above the upper border of the patella through skin and muscle down to bone. The femoral artery and vein are doubly ligated and the tourniquet released. Hemostasis is affected, and with a small knife a circular incision is made into the periosteum. The periosteum is reflected first with an angular periosteal elevator, then with gauze to a

FIG. 5.

FIG. 6.

FIG. 7.
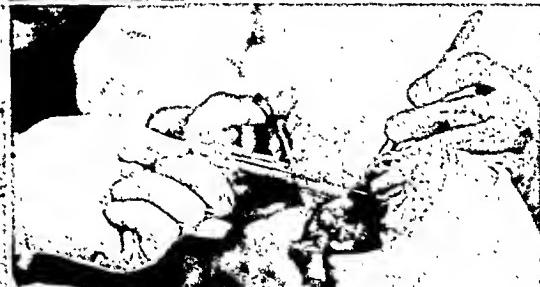
FIG. 8.
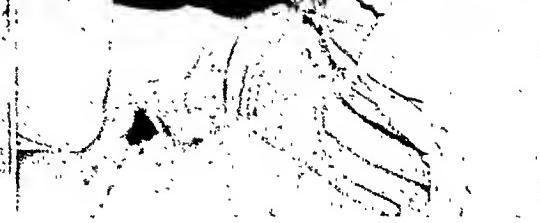
FIG. 9.

FIG. 10.

FIGS. 1 TO 10. Ten steps showing simplified supracondylar thigh amputation.

	No. of Cases	Infected	Clean	Mortality Within Three Days Postoperatively	Total Mortality, Including Deaths in the Hospital Following Discharge from Our Surgical Wards
First period (1916–1939)	49	23 (58.96%)	16 (41.4%)	10 (20.4%)	25 (51.02%)
Second period (1940 and 1941)	24	6 (25%)	18 (75%)	0	9 (37.50%)

distance of four-finger breadths proximal to the initial incision. The stump is protected and the bone is sawed off. Muscles, fascia lata and skin are approximated anteroposteriorly. It is important to suture all opposing muscles together, so that the patient may have proper control of the stump. The principal, "The less exposure of wound, the less chance of infection," is made full use of, hence, the division of the operation into steps and the speed with which each step is executed. (Figs. 1 to 10.)

Unless the sciatic nerve protrudes into the wound, it is left alone, otherwise, it is pulled out and cut short. The suture line in the skin is covered with vaseline and protected with a sheet of cellophane. Vaseline retards adhesion of the edges and promotes oozing; the cellophane permits inspection of the wound without contamination, and a painless change of dressing when the sutures are removed. No posterior splint is used, though at times a soft pillow is placed beneath the stump for comfort.

The above table has been compiled from charts available at the record room, of cases that had had thigh amputations on our service during the past six years. The comparison is made between two periods. The first period is from 1936 to 1939 inclusive, before we had standardized our procedure for handling these cases. The second period includes 1940 and 1941, during which period, the technic described in this paper had been adopted routinely.

The mortality in both groups seems high, but when one considers the type of neglected and often moribund patient, who at last lands in a city hospital after he wastes his money on new salves and gives his last penny to the professor who is going to save his leg, and who even after admission to the hospital continues to refuse operation until the odor has exhausted all the deodorants on the ward and has become unbearable to the patient and his family, one realizes that it is not as bad as it might seem at first glance.

SUMMARY

Six years of experience on the surgical and diabetic wards of the Kings County Hospital have taught us the following:

1. Lesions in the extremities are best classified as vascular, infectious or mixed, with or without metabolic derangement.

2. Diabetes need not be considered when the question of local therapy arises. The choice of conservative or radical therapy depends principally upon the nutrition of the extremity.

3. Physiotherapeutic measures are unreliable and only useful in keeping the patient occupied while the surgeon makes up his mind.

4. Conservative therapy that has been of some help in our hands has been discussed.

5. The technic that in our hands has decreased the mortality and morbidity of amputations has been described.

REFERENCES

WILLIAMS, F. W. and O'KANE, T. J. Clinical classification of lesions of the lower extremity associated with diabetes. Arch. Surg., 4: 366–371, 1940.
TENOPYR, O. and AL AKL, F. M. The ideal dressing for clean wounds. Am. J. Surg., 51: 399, 1941.

CEPHALIC BRUIT

A REVIEW OF THE LITERATURE AND A REPORT OF SIX CASES

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NORMAL blood passing through smooth-walled vessels at an average rate of speed and without sudden changes in direction of the current seldom, if ever, produces a murmur detectable by ordinary methods of auscultation. There are, however, a great variety of anatomical anomalies as well as numerous pathological states of the blood vessels (less frequently alteration in the blood itself) that result in a bruit audible over the implicated area and/or transmitted along the vascular current. Abnormal states of the vascular system in the intracranial cavity offer no exception, cephalic bruit occasionally being heard by auscultation of the head. Cushing and Bailey[1] commented "by a strange human frailty, auscultation of the skull seems to be the one thing most likely to be neglected in a routine neurologic examination." If an intracranial murmur is heard, the entire cranium should be auscultated in order to determine the point of greatest intensity of the bruit. In the normal human subject no audible sounds are heard over any part of the head. However partial obstruction to the nasal air passages or labored breathing frequently results in a respiratory murmur transmitted to all parts of the calvarium. These observations have been substantiated by many clinicians, yet this important step in the examination is still frequently omitted.

Various methods of cranial auscultation have been described, each possessing certain advantages. The oldest one is that of placing the ear of the examiner against the ear of the patient. Using a stethoscope with a diaphragm enables one to hear a bruit more often than with the bell-type stethoscope. Still,[2] describes an ingenious device by which two sets of ear-pieces are joined without an intervening chest-piece, with one set being placed in the examiner's ears and the other in the ears of the patient. For routine examination it is advisable to auscultate over five areas of the head: in the middle of the forehead, anterior part of the temporal fossae and just posterior to either mastoid eminence. When auscultating over the lateral occipital region care must be exercised so as to prevent partial occlusion of the greater occipital artery, since a systolic bruit may be inadvertently produced thereby.

In pathological states or where there are anatomical anomalies of the blood vessels of the intracranial cavity, the commonest mechanism for the production of a murmur is the entrance of blood into a zone of greater caliber than that through which it has just passed. For example, an arteriovenous fistula, an aneurysmal varix or a tumor creating wide vascular channels resulting in rapid eddying currents of blood, produce audible cephalic bruit. In the absence of obvious pathological lesions there are certain physical properties contributory in the production of audible bruits. These are: abnormalities in the rate of flow and modifications in the viscosity of the fluid, variations in the distensibility of the channel, and sudden changes in the direction of the current.

Fisher[3] described several cases of cephalic bruit and concluded that the murmur is indicative of organic changes (notably hydrocephalus, meningitis or brain abscess) and is due to pressure of the distended brain on the arteries at the base. However, from a review of the literature it may be said that intracranial bruits in children are often without pathological

significance. To bear out this contention Hamburger[4] cites Osler who "described a case of a healthy 3 year old child with a loud systolic head murmur which was heard by the mother and at times by the child. The murmur could be heard anywhere over the head and ceased on compression of the carotids. The medical attendant had suggested the possibility of aneurysm but Osler, basing his view on the knowledge of the literature at the time gave a favorable prognosis. The mother did not appear satisfied and Dr. Osler heard nothing further of the case for some months when he recognized it 'in the description of a Case of Supposed Gummy Tumor of the Brain in which the murmur was attributed to the possible existence of a syphilitic growth pressing upon the vessels at the base of the brain.' In spite of the two opinions dissenting from Dr. Osler's the child thrived, and when last seen at the age of 7, still had an audible bruit." Still described the case of a healthy boy aged 8, who heard noises in his head and especially in the region of the left ear which were sufficiently distracting to keep him awake at night. A loud systolic murmur was audible by pressing the right ear of the examiner to the left ear of the patient. The presence of a pathological condition to account for this was doubted. Henoch[5] heard cranial bruits in twenty-four out of thirty-three rachitic children, all of whom had open fontanelles. He therefore concluded that rickets is the prime factor in the production of a cephalic murmur. Roger[6] had two patients thirteen and fourteen years of age with marked anemia, both of whom had bruits heard over the frontal and temporal regions. He concluded that in both of his cases and those of Henoch the murmur was due to the anemia accompanying rickets. In support of the idea that anemia can cause cranial bruit a case of Hamburger may be cited. A woman twenty-three years of age with a hemoglobin of 40 per cent and 1,650,000 erythrocytes had a very loud blowing systolic cranial bruit. Still reported a series of 130 infants with closed fontanelles, thirteen of whom had audible cranial bruits, and seventy infants with open fontanelles, of whom seventeen had bruits. Many of these children with murmurs were in apparently perfect health, and the rest were suffering from a wide variety of ailments. Still, Hamburger and others speculate that the frequency of intracranial bruits in children without evidence of organic disease is perhaps due to a "temporary stenosis" of the carotid artery in the carotid canal; i.e. the canal does not enlarge as rapidly as the artery. As an alternative they express the opinion that the carotid artery grows faster than the skull in the early years of life and because of this the artery is apt to become tortuous at the base of the cranium. Later, as the skull enlarges, the artery is enabled to assume a straighter course.

Communications between cephalic arteries and veins, both intra- and extracranial, often give rise to loud murmurs, both subjective and objective. These arteriovenous fistulas are mostly traumatic, but may be congenital or spontaneous. In its commonest form, an anastomosis is created between the internal carotid artery and the cavernous sinus. Pulsating exophthalmos frequently results from this lesion. Hamburger reported a case of this kind, the result of trauma without exophthalmos, in which the murmur, both subjective and objective, persisted nineteen years. Rienhoff[7] also reported a case with a loud cranial bruit which he states was the first intracranial arteriovenous fistula extirpated successfully. Following surgical removal of the fistulous tract the murmur ceased. Pulsating exophthalmos and cranial bruits are infrequently associated with aneurysm of the internal carotid artery, orbital neoplasm and aneurysm of the ophthalmic artery. Bruits are also found in cases of congenital vascular malformations, certain tumors of vascular origin, meningiomas and vascular gliomas. Meyer[8] reported a case in which a glioma overlying the floor of the fourth ventricle was associ-

ated with an audible bruit. It would seem that in most of these cases the murmur is attributable not to the vascularity of the tumor *per se*, but rather to a disturbance of the circulatory dynamics of that region of the brain. A case reported by Hamburger bears out this contention. This patient had a "cerebral glioma with a large cyst in the absence of undue vascularity." Pressure over the right carotid artery caused the murmur to disappear, and pressure over the left carotid diminished the intensity of the bruit. Subtemporal decompressions were performed, the right carotid was ligated, and the bruit ceased for a few days but returned. "The autopsy performed immediately after death and without preliminary fixation of the brain, revealed a very marked displacement downward of the hind brain into the foramen magnum with angulation of the vertebral arteries which had been dragged downward into the vertebral column to a point sufficient to produce angulation of these vessels. This herniation was found to be due to the very high position of the neoplasm, which was located chiefly in the midline. The usual dilatation of the ventricles was present." Beadles[9] has reviewed 555 cases of intracranial aneurysm (not arteriovenous aneurysms) verified as such at autopsy. Murmurs were heard in only two of these. One was an instance of an aneurysm of the vertebral artery, the other an aneurysm of the cavernous portion of the internal carotid. The patient with an aneurysm of the vertebral artery was a male sixty-one years of age with mitral disease. Four days before death, a loud murmur was heard on each side of the cranium between the mastoid process and midline of the neck. At autopsy, an aneurysmal dilatation of the left vertebral artery causing a shallow depression on the anterior surface of the medulla was discovered. However, two other cases of larger aneurysms of the vertebral artery were found in which no cranial bruit was audible. Hutchinson[10] reported a case in which the symptoms were headaches (of

ten years' duration), throbbing of the temples, beating in the ears and blurring of vision. The objective signs were paralysis of the structures supplied by the left III and VI cranial nerves. There was a loud bruit audible over both ears. At autopsy, a dilatation of the cavernous portion of the internal carotid artery overlying the gasserian ganglion was discovered. Hamburger cited a case in which there was an aneurysm of the anterior cerebral artery, which pursued an abnormal tortuous course.

Cranial bruits occur most frequently in children between the ages of two months and six years, with the greatest incidence during the second year of life.[2] They have been occasionally reported in adults, remaining for a period of months or years, and then disappearing as mysteriously as they arose. A certain number of these are probably due to arteriovenous fistulas being created between the cavernous sinus and the internal cartoid artery, sometimes indicated by the presence of pulsating exophthalmos,[11] with subsequent spontaneous healing.

REPORT OF CASES

During my internship at The Brooklyn Hospital, it was my privilege to observe six patients with cephalic bruit on the service of Dr. E. Jefferson Browder of the Neurological Unit. Five were adolescents and one was an adult. The following are the case reports:

Case I. D. S., an eight year old boy was admitted July 13, 1938. The past history revealed that the boy had been in good health until ten months previous to admission when he started to have occasional attacks of vomiting. An exploratory laparotomy was performed at another hospital but did not reveal the causative factor. The child then developed increased irritability, violent headaches, inability to see objects to his right, drowsiness, emotional instability, enuresis and a tendency to fall to the right. On admission at this hospital, physical examination revealed an ataxic gait, the patient falling most often to the right. Over the left parieto-occipital region there was an

audible high-pitched, distant puff-like, resounding bruit, synchronous with the pulse and audible only with the diaphragm and not with the bell type of stethoscope. There were marked bilateral choked disks but the visual fields were grossly normal. There was moderate adiadochokinesis, ataxia of both lower extremities, inconsistent past pointing and marked loss of muscle check movements. The right superficial abdominal reflexes were absent. A ventriculogram showed marked internal hydrocephalus with great dilatation of the lateral, third and part of the fourth ventricles. A cerebellar decompression was performed. The vermis was split in the midline. A steel gray vascular tumor the size of a lemon was exposed extending out of sight along the floor of the fourth ventricle cephalad. Most of the tumor was removed except that directly approximated to the medulla. Microscopic studies of sections of the tumor confirmed the clinical diagnosis of medulloblastoma. Following operation the bruit disappeared, and after a course of roentgen ray therapy the patient improved and was considered to be in fair physical condition, without return of the murmur.

CASE II. G. W., a twelve and one-half year old white schoolboy, was admitted on October 14, 1930, with a three year history of intermittent headaches, lasting several hours, and as the boy had a chronic post-nasal drip, they were attributed to sinus trouble. Four months prior to admission the headaches, which were confined to the left side of the head, became much more severe and were accompanied by easy fatiguability and projectile vomiting without nausea. He then developed transient diplopia, the right eye turned in, his gait became unsteady, and there was paresis of the right arm. Physical examination on admission showed a prominence of the right frontal region. A bruit was heard over the occipital region bilaterally. This bruit ceased on compression of the left carotid artery but its intensity was not influenced by compression of the right carotid. The child showed a dull mentality (but had reputedly been very alert and in fact precocious prior to the present illness). There was a right homonymous hemianopsia, and inability to recognize test odors. There was a right facial paresis of the supranuclear type. There were occasional jerky movements of the head and all four extremities, and impairment of coordination of movements of the right upper

and lower extremities. The deep reflexes were depressed on the right and exaggerated on the left. Roentgen-ray studies of the skull showed halisteresis and a large calcific deposit lying above the sella turcica with erosion of the sella. On October 16, 1939, a right frontal craniotomy was performed, and on retraction of the right frontal lobe a reddish-grey tumor about 3 cm. in diameter was found between the optic nerves anterior to the chiasm and occupying the space of the eroded sella. The anterior horn of the right lateral ventricle was opened and the third ventricle entered by enlarging the foramen of Monro. A tumor mass was disclosed which filled the inferior portion of the third ventricle, and was taken to be a craniopharyngioma, portions of which were removed for histologic study. The postoperative course was very stormy, with an episode of respiratory failure three days postoperatively. Seven days after the operation the patient developed a massive atelectasis and expired. Autopsy was not obtained.

CASE III. L. D., a six year old white female, was admitted on August 5, 1939. Two weeks prior to admission the child had a severe frontal headache which lasted three days and then disappeared completely. During that time, and for the remainder of the week she vomited several times daily. For one week prior to admission she complained of diplopia and the left eye was turned in. On physical examination at the time of admission a bruit of moderate intensity was heard over both temporal areas and over the occiput in the superior nuchal line. Pressure on the right carotid produced little change. There was a left internal strabismus and a left inferior homonymous quadrantal defect. The fundi showed marked bilateral papilledema with engorged veins. A ventriculogram performed on August 7, 1939, disclosed a soft tissue mass in the midline occupying the posterior three-quarters of the third ventricle. On the same day a right frontal craniotomy was done. An area of frontal cortex was excised and the frontal horn of the right ventricle was entered. The third ventricle was exposed through the foramen of Monro, and a tough, yellow, gelatinous tumor mass about 2.5 cm. in diameter arising from the floor and left anterior walls of the ventricle was excised. On histologic study the tumor was diagnosed to be a fibrillary astrocytoma. The patient made a fairly uneventful recovery, but was left with considerable intellectual impairment and a minimal left

hemiparesis. She has been followed in the out-patient department and when last seen on June 20, 1940, no bruit was audible.

CASE IV. M. H., an eight year old white schoolgirl, was admitted on March 23, 1939, with a two months' history of suboccipital pain, dull and nonradiating in character. Two weeks after the onset of the pain the patient began to have frequent episodes of nonprojectile vomiting, accompanied and preceded by a short period of nausea. For one week prior to admission the patient had some unsteadiness of gait resulting in several bad falls. On physical examination at the time of admission the child was found to have an inconstant rough bruit distantly heard over the left occipital region. There was a 4 plus papilledema bilaterally, and a coarse nystagmus in all directions. A mild ataxia and apraxia were noted, as well as a bilaterally positive Babinski response. After shaving the head a decided bulge was noted over the occiput. On March 27, 1939, an occipital craniotomy was performed, and on retracting the cerebellar lobes, a bluish red, irregularly nodular and somewhat cystic tumor was disclosed in the midline, occupying most of the fourth ventricle. It was attached to the floor of the fourth ventricle over an area about 1 by 1 cm. in diameter, slightly anterior to the lateral recesses, and to the anterior inferior part of the right cerebellar hemisphere. As much as possible of the tumor was removed which on pathologic study proved to be an unclassified type of glioma. The child made an uneventful recovery and except for some mild ataxia and nystagmus was well at the time of the last examination in September, 1941. No cranial bruit was audible.

CASE V. F. W., a fourteen months old white male infant, was admitted on October 6, 1939, with a history of having fallen down a flight of stairs and striking his head on a concrete floor three days previously. He began to cry immediately after the accident and then lost consciousness for a few minutes. The night following the injury he began to develop weakness of the left arm and leg which became more pronounced up until the time of admission. At the same time he developed conjugate deviation of the eyes to the right. On admission there was a loud rough bruit audible over the entire head and loudest at the right temple. There were numerous fresh hemorrhages in the right fundus. There was a relative prominence of the right

frontal and temporal regions. The scalp was reddened and edematous over the entire left parietal and upper occipital and temporal regions. The anterior fontanelle was tense and bulged up above the level of the surrounding scalp. There was a left facial paralysis and no spontaneous movements of the left arm, hand or leg. The deep reflexes in the left upper extremity were sluggish. A right parietal craniotomy was performed on October 9, 1939, and a subdural layer of thick, tarry old blood was encountered over the parietal, occipital and temporal fossae, which was washed away with saline. The total amount of blood was estimated at 50 cc. The patient made an uneventful recovery, regaining the use of the left arm and leg prior to discharge. No bruit was heard at the time of discharge.

CASE VI. F. R., a twenty-three year old white female schoolteacher, was admitted for the first time on September 3, 1936. At that time she gave a history of a fall five years previously, when she struck her head severely, and was momentarily dazed. Four weeks later she suddenly had a generalized convulsion, with loss of consciousness, and from then on experienced two or three such seizures every year. She also suffered almost daily attacks of petit mal during which she would be unable to move or speak for several minutes. The second year of her seizures she began to take phenobarbital, was free of attacks for eighteen months and was able to return to school. Following this period the attacks returned in a much milder form, and at the time of the first admission the only abnormality noted was a slight left facial weakness and a partial right homonymous hemianopsia. An encephalogram demonstrated an asymmetrical cerebral ventricular system, the right anterior and posterior horns being smaller than the left. A right temporal craniotomy on October 14, 1936, disclosed a hemangioblastic malformation in the region of the right Sylvian fissure. Nothing other than visualization of the lesion was attempted at this time. On November 3, 1938, the patient tripped and fell down a flight of stairs, striking her right hand which she had raised to protect her head, and sustaining a Colles' fracture of the right wrist. In December of that year she began to have recurrences of convulsions and her students noticed that she dropped things out of her hands with abnormal frequency. In July, 1939, as a preliminary step for ligation

of the right internal carotid artery, she was instructed to carry out intermittent compression of the common carotid on this side. She was readmitted on September 19, 1939, and at this time it was noted that at a point 4 cm. antero-superior to the upper edge of the right ear, a soft bruit was heard, synchronous with the carotid pulsations in the neck. Moderate pressure on the right common carotid artery modified the quality of the bruit to a whirring noise. The patient seemed immature mentally, talkative, and at times silly. There was a slight left facial weakness. The Romberg test was positive. On September 20, 1939, the right internal carotid artery was ligated under local anesthesia without producing any untoward symptoms. The patient was discharged on Oct. 2, 1939, without having had any further convulsive seizures. However, the bruit was still audible.

In reviewing the literature on the subject of head murmurs, no definite conclusion could be drawn as to the incidence of bruit in the population at large as compared with its occurrence in the patient suffering from an intracranial lesion. Accordingly, it was suggested that auscultation of a large enough series of individuals would furnish some information on this point. The group so examined were:

100 ambulatory patients from The Brooklyn Hospital Cardiac Clinic, suffering from all the common varieties of heart disease

75 patients from the Medical and Surgical wards of The Brooklyn Hospital

75 apparently healthy persons from the personnel and professional staffs of the hospital.

The technic of examination consisted of auscultation over the frontal, temporal and parietal regions, with the patient in the prone and sitting positions, and in the erect position after one minute of running in place.

Of the seventy-five healthy persons examined, not one had an audible cephalic bruit. Of the seventy-five hospital patients examined, one boy eleven years old with the very loud presystolic murmur of advanced mitral stenosis, had a very faint high-pitched bruit over the right temporal region only while lying in the left lateral position. The bruit was synchronous with the heart murmur. Of the one hundred patients examined in the Cardiac Clinic, two patients with cephalic murmurs were encountered, one in a patient with advanced mitral stenosis and aortic insufficiency (a female twenty-six years of age). When examined in the sitting position, a faint, high pitched bruit was audible over the right temporal region, synchronous with the presystolic heart murmur. The other was in a man of sixty-three who had advanced hypertensive and arteriosclerotic cardiovascular disease with a blood pressure of 240/180. There was a rather rough, faint, low-pitched murmur heard over the left parietal region in this case. None of these three patients had any neurological complaints, except the last who had occasional tinnitus and vertigo, with severe frontal headache. Examination in all three patients revealed no abnormal neurological findings.

SUMMARY AND CONCLUSIONS

It appears that cranial auscultation is a "near forgotten art." This method of examination is seldom employed by the average practitioner although simple of execution, and from such an examination one may derive valuable information. The pertinent features of the subject as recorded in the literature have been reviewed. Six examples of intracranial bruit occurring in patients harboring intracranial lesions have been reported in order to illustrate some of the pathologic states that may result in a bruit. In an endeavor to estimate the frequency of occurrence of this abnormal physical finding in persons not exhibiting signs of intracranial disturbances, the heads of 250 persons were auscultated. Cephalic bruit was demonstrated in only three instances (0.012 per cent) and in two of these cases there was a murmur audible over the heart, the great vessels of the neck and the head. From the

evidence at hand, it seems logical to conclude that a cephalic bruit in any individual merits careful consideration and further investigation of the possible presence of an organic intracranial lesion.

REFERENCES

1. Cushing, H. and Bailey, P. Tumors arising from the blood vessels on the brain. P. 71, 1928.
2. Still, G. F. *Brit. J. Child. Dis.*, 18: 173, 1921.
3. Fisher, J. D. *Am. J. M. Sc.*, 44: 24, 1938.
4. Hamburger, L. P. *Am. J. M. Sc.*, 181: 756, 1931.
5. Henoch. *Beitr. z. Kinderb.*, 1861, 170.
6. Roger. *Recherches Clin. sur les maladies de l'enfance*, 103: 29, 1883.
7. Rienhoff, W. F., Jr. *Bull. Johns Hopkins Hosp.*, 35: 271, 1924.
8. Meyer, A. *Arch. Neurol. & Psychiat.*, 4: 387, 1920.
9. Beadles, C. F. *Brain*, 30: 285, 1907.
10. Hutchinson. Cited by Oliver, C. A. *New York State J. Med.*, 79: 691, 1904.
11. deSchweinitz and Holloway. Pulsating Exophthalmos. Pp. 38 and 71, 1908.
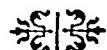
Chronic osteomyelitis is always a slow process. Complete healing never occurs until all sequestra have been removed, or sloughed out, and subsequent recurrence of the condition by lighting up of latent infection is common. This may happen many years after the original infection has healed.

From—"A Manual of the Treatment of Fractures"—by John A. Caldwell (Charles C. Thomas).

PROLONGED STUPOR PRODUCED BY SUBDURAL HYGROMA*

RELIEF BY TREPHINE AND DRAINAGE

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THE subdural space which lies between the arachnoid and dura mater normally contains a thin layer of fluid called subdural fluid (Weed, Penfield).[1]

Although the mechanism of production and accumulation of this subdural fluid is not known, it is definite that following a head injury there may be an accumulation of fluid in the subdural space which takes up volume and exerts pressure against the brain in a manner similar to subdural hematoma or clot.

The term chronic subdural hydroma or hygroma, meaning an excessive amount of clear fluid in the subdural space following a head injury, was first introduced by Dandy.[2] Since then this condition has been described by Naffziger, Fay, Cohen, Walsh and Sheldon, Love and others.[3,4,5,6]

It is the purpose of this paper to present three cases of head injury showing prolonged stupor produced by subdural hydromas and relieved by simple trephine and drainage of the subdural space.

CASE REPORTS

CASE 1. A child, aged two, was admitted on June 5, 1935, with a history of inability to talk, weakness and fine purposeless movements of his right hand and arm. On May 10, 1935, he had been struck by an auto and on the second day after the accident the child had a right-sided convulsion. He was then unconscious for five days. An x-ray of the skull showed a linear fracture of the left frontal bone and the left femur. The sixth day after the accident the child appeared to regain consciousness and spinal puncture revealed slightly blood-tinged fluid. Eight days after the accident it was noticed that the left pupil was dilated and was fixed to light. Another spinal puncture done at this time yielded 18 cc. of moderately bloody spinal fluid. The patient began to improve gradually but because of the aphasia, weakness of the right arm and choreaform movements of the right upper extremity, he was hospitalized about twenty-five days after the accident.

Examination. The child appeared to understand simple commands but could not talk. He would extend his tongue when requested to do so. There was dullness to percussion, bilaterally, over both frontal regions. The pupils were both dilated but reacted well to light. There was no co-operation to accommodation. The discs showed no choking and the ocular movements appeared normal. There seemed to be relaxation of the left lower one-third of the face. The deep tendon reflexes were bilaterally hyperactive. Hoffman and Babinski signs were not present. Forced grasping with cog-wheel rigidity was present in the right upper extremity. Muscle power was decreased in this extremity and choreaform, purposeless movements were present. X-ray showed a linear fracture of the left frontal bone.

An exploratory trephine was done in the left temporoparietal area by Dr. Fay one month after the accident and four ounces of clear subdural fluid was evacuated from the subdural space. There was no evidence of any subdural bleeding or clot.

On the fourth postoperative night the child called "Mama." On the tenth day after the operation the child could speak small sentences and two syllable words. The patient was discharged on the eighteenth day sitting up and talking. There was still some ataxia in the right upper extremity.

When seen again three months later, he was running about, alert, and could recite many small poems.

CASE II. J. K., aged nineteen, was admitted on July 11, 1939, because of unconsciousness for a period of twenty-three days. On June 18th the patient fell and struck his head. He was taken to a hospital unconscious, in shock and bleeding from the right nostril. A spinal puncture done at this time showed very bloody fluid. The examination revealed pupils equal in size and there were no recorded signs of any abnormal neurological findings except for the stupor. An x-ray of the skull showed a fracture of the right frontal bone extending into the orbit. There was no depression of fragments. Repeated spinal punctures were done. However, his condition did not improve and he was sent to the neurosurgical service of Temple University Hospital twenty-three days after the accident.

Examination. When first seen, the patient was unconscious, tossed about the bed, his mouth was opened and relaxed. Percussion of the head showed dullness in the left parietal region. The pupils were equal, regular and reacted to light. The right side of the face appeared relaxed. On passive elevation the right upper extremity fell more limply than the left suggesting weakness of the right arm. The deep tendon reflexes were slightly increased on the right and a Babinski and Oppenheim sign were present on this side. There was slight eversion of the right lower extremity. The eyegrounds showed no choke.

Temperature was 102°F., pulse 100, respirations 20 and blood pressure 120/80. Spinal puncture yielded only a few cc. and the fluid was clear. The pressure was low. The x-ray of the skull showed a fracture of the right orbit and the left frontal bone. The pineal gland could not be visualized.

Operation. A diagnosis of subdural hematoma on the left, possibly bilateral, was made and twenty-six days after the accident a bilateral trephine was done by the writer. An opening was made over the left temporofrontal area. The dura was slightly tense and about 3 mm. in thickness. The cortex appeared pale, the gyri flattened, and the pial capillaries decreased in number but congested. The brain was gently retracted and about three ounces of clear subdural fluid evacuated. A drain was placed in the subdural space and carried out through the

incision. A similar trephine opening was made in the posterior parietal region on the right. The dura was only moderately thickened. The cortex again appeared pale. Only one ounce of clear subdural fluid was found on this side.

Clinical Course. Following the operation the patient made a gradual convalescence. On the third day postoperatively the patient said "yes" to his nurse when asked if he wished to see his mother. He was discharged three weeks after the operation markedly improved. He could walk with support, he was alert and interested in his environment but showed a partial aphasia. There was still some retardation and weakness of the right leg present. When seen one year later the patient had made a complete recovery. He was keen mentally and had no complaints except for occasional headache.

CASE III. F. C., male, aged sixty-nine, was admitted on September 19, 1939 with a history of stupor following a head injury twenty-eight days prior to admission. The patient was injured in a train wreck and was unconscious for forty-eight hours. He then regained consciousness and talked but gradually failed for the next ten days and he had been unconscious for approximately sixteen days when he was admitted to Temple University Hospital.

Examination. The patient was stuporous on admission. The pupils were miotic (patient had received a sedative for the trip, morphine). There was dullness on percussion of the left side of the head. There appeared to be slight weakness of the right lower face on expressional movement to painful stimuli. All extremities were moved on painful stimuli but the right lower extremity was not moved as well as the left. A bilateral Babinski and Chaddock sign were present. Temperature was 102°F., pulse 90, respirations 16 and blood pressure 120/70.

X-ray revealed a fracture in the left temporal bone but no shift of the pineal gland. A diagnosis of subdural hematoma was made and operation was done by Dr. Temple Fay.

Operation (One month after the injury). A trephine was done over the left midfrontal area. The exposed dura was light green in color. Upon its incision a fine membrane was seen. Upon opening this membrane there was a gush of golden yellow subdural fluid. At least three ounces was aspirated before the cortex could be seen, almost an inch from the dura. This space was drained but the patient did not

improve materially. Five days later a trephine opening was made over the right posterior superior parietal area and a similar cyst was encountered. About four ounces of subdural xanthochromic fluid was removed. The patient then had a stormy convalescence but finally made a complete recovery and walked out of the hospital on October 18, 1939, one month after his admission and two months after his injury.

The bilateral, equal collections of subdural fluid accounted for the lack of shift of the pineal gland. The subdural fluid in this case showed 3000 and 5000 mg. of protein per 100 cc., respectively.

CONCLUSIONS

Three cases of head injury having histories of prolonged periods of unconsciousness are presented. In two cases large collections of clear subdural fluid were found and drained; in one the classical type of zanthochromic subdural cyst was found. In every case the patients returned to consciousness following the drainage.

Since an ounce of clear fluid takes up just as much space as an ounce of blood or clot, it can be seen that these subdural hygromas produced symptoms identical to those of subdural hematoma. This type of lesion should be suspected in every case of head injury which does not show the usual trend to recovery after proper measures for relief of intracranial pressure and edema have been used.

The treatment is similar to that used in liquid subdural hematomas. An exploratory trephine or Hudson burr opening is made usually over the posterior superior part of the parietal bone. The dura is opened, the subdural fluid evacuated, and the subdural space drained for twenty-four to forty-eight hours with a small cigarette drain. If excessive fluid is not found on the suspected side, or relief has not been obtained three to five days after one side has been drained, the opposite side should be inspected.

REFERENCES

1. PENFIELD, WILDER. *Anat. Rec.*, 28: 173, 1924.
2. LOVE, J. S. Bilateral chronic subdural hydroma, *J. Nerv. & Ment. Dis.*, 85: 161–166, 1937.
3. NAFFZIGER, H. C. Subdural fluid accumulation following head injury. *J. A. M. A.*, 82: 1751–1752, 1924.
4. FAY, TEMPLE. Personal communication.
5. COHEN, IRA. Chronic subdural accumulation of spinal fluid after cranial trauma. *Arch. Neurol. & Psychiat.*, 18: 709–723, 1927.
6. WALSH, M. N. and SHELDON, C. H. Acute subdural hydroma. *Proc. Staff Meet., Mayo Clin.*, 12: 134–136, 1937.

A METHOD OF SUSPENDING THE UTERUS WITHOUT OPEN ABDOMINAL INCISION*

USE OF THE PERITONEOSCOPE AND A SPECIAL NEEDLE

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ONE of us (J. K. D.) while doing closed intrapleural pneumonolysis operations with a thoracoscope in 1938, conceived the possibility of accomplishing the Olshausen suspension of the uterus without abdominal incision; and devised a needle (Fig. 8) whereby this could be done by utilizing the peritoneoscope.

Before attempting the operation upon human beings, we ran a series of experiments with twenty dogs investigating the feasibility of technic and the density and permanence of fixation between the round ligaments and the abdominal wall as achieved with the Olshausen suspension. (Fig. 1.) Experimental investigation as to the density and permanence of fixation was, in one sense, unnecessary since the Olshausen has been accepted as a legitimate method of suspension of the uterus for many years. (The two horns of the uterus of the dog were suspended as a correlation to suspension of the round ligaments in the human.)

It is to be remembered that Graves listed the Olshausen as his suspension of general preference in his textbook of gynecology.[1] And since the end results of the procedure we describe are the same exactly as those of the Olshausen, we feel more secure in presenting this method than if it were a new operation instead of a new technic for doing a procedure which has been accepted for many years.

We do not choose to enter here into the long standing discussion relative to the advantages of different types of suspensions. We are well aware that each gynecologist and surgeon is inclined to be dogmatic regarding his particular preference. Suffice it to say that the two senior authors have preferred the Olshausen and Gilliam, respectively, for many years. And if one should prefer the latter, it, too, as suggested by one of us (J. H. S.) can be done with the peritoneoscope without openly incising into the peritoneal cavity. Furthermore, we believe modifications of the Alexander suspension could likewise be done though we have not experimented in this regard.

ADVANTAGES OF THE OPERATION

Intestinal obstruction is not an especially frequent sequela of abdominal adhesions but it is certainly a serious disorder when it occurs. For this reason if for no other, any surgical procedure which will diminish the extent and incidence of adhesions deserves consideration, everything else being equal. Certainly there is much less raw surface created in this operation than with one in which an incision several inches in length is made into the peritoneal cavity.

After routine diagnostic peritoneoscopy, Ruddock and others permit the patient to become ambulatory immediately. The

possible interference with the attachment of the round ligaments. In considering this question we reached a tentative conclusion that the weight of the uterus on the round ligaments and the stitches used for suspending it, would be little if any more with the patient in an upright position than with the patient lying in bed upon her back. Consequently we have permitted our patients to become ambulatory within twenty-four hours after the operation or as soon thereafter as they desired. Some of them who are more sensitive to pain elect to stay in bed four or five days but the majority have elected to become ambula-

where the stitches have been inserted through the rectus muscles; and when tension is produced upon the recti, it will cause some discomfort for ten to eighteen postoperative days. But this discomfort is not marked as a rule, not at all comparable to the pain and soreness which follows open incisions.

There is no shock to the procedure we describe and no reason for keeping the patient in the hospital more than twenty-

conditions. However, most physicians and surgeons agree that the majority of marked retroversions of the uterus do cause low
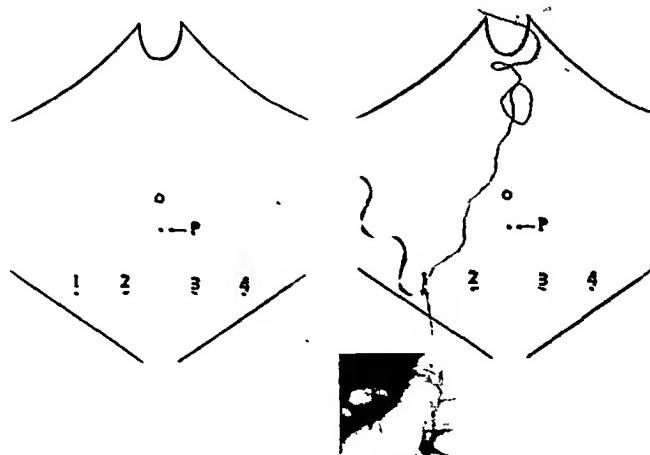
FIG. 3.   FIG. 4.

Fig. 3. o represents the umbilicus; and points 1, 2, 3 and 4, indicate on each side the sites of entrance and exit from the abdominal wall of the needle point. By proper manipulation, it is possible to have the sites of entrance and exit of the needle upon the inner aspect of the abdominal wall about one-half inch apart. This photograph is incorrect in our revised technic in that P is no longer used as the site of introduction for the peritoneoscope. Since the peritoneoscope is rather long, we now elect to introduce it about one inch above the level of the umbilicus through the middle of the left rectus. If one introduces it at the point P, the lens of the instrument will frequently impinge upon the structures of the pelvis and interfere with vision.

Fig. 4. The knife-edged point of the needle is illustrated as puncturing the skin at point 1. The point will be carried directly through the abdominal wall and passed around the round ligament under peritoneoscopic vision. The needle point will then be directed out at site 2.

four to forty-eight hours. The latter, of course, effects an appreciable economic saving.

There is less likelihood of contaminating the abdominal wall structures and peritoneum than in an open operation, and obviously there should be a decreased incidence of postoperative hernia and postoperative laxity of the abdominal wall of which some women complain after open incision. Of course we appreciate that these latter arguments are minor.

INDICATIONS FOR OPERATION

We do not claim that this procedure has a tremendously wide applicability. We know that a certain percentage of retroverted uteri do not give symptoms and do not create additional pelvic pathological
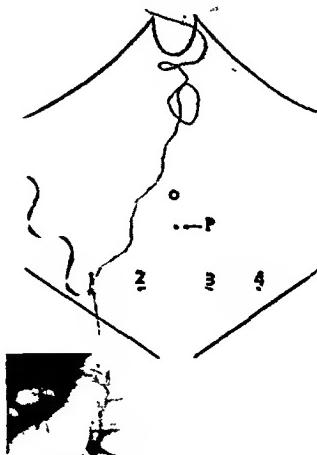
backache, predispose to general irritability of the nervous system, as well as to cystic degeneration of the ovaries. It would be academic to enter further into a discussion of signs, symptoms and pathologic physiology of a subject which has been as thoroughly discussed as retroversion of the uterus.

In short it may be said that consideration of this operation is indicated in any case in which surgery would be advised for retroversion alone. We will venture to say that we would recommend this procedure a little more quickly than we would open abdominal incision operations since the advantages, as outlined above, make it a less annoying procedure to the patient as well as a less dangerous one. In this sense we believe that possibly the operation could

as it usually is, it obviously should be done. If one accepts the dictum that perineorrhaphy alone will keep a patient in bed for two weeks, some of the value of the suspension by peritoneoscopic method will have been lost. We cannot but present the method, however, with reserved enthusiasm and definitely believe that if those operators experienced in peritoneoscopic and gynecologic surgery will familiarize themselves with it, they will grant it a limited but definite place in the surgical armamentarium.

As indicated by the few cases which we report at present, we have selected carefully the patients upon whom we have done this procedure. Out of a rather active clinical and hospital service we have uterus giving signs and symptoms warranting open abdominal incision, and in each patient there was no other intra-abdominal pathological condition which indicated operation. The operation has been successfully executed in every case, and the uterus has remained firmly suspended to date in its new position despite the fact that we have permitted the patient to become ambulatory within the time limits mentioned above.

TECHNIC

Those not familiar with the use of the peritoneoscope can scarcely appreciate the ease with which this operative procedure can be accomplished by one experienced in peritoneoscopy. Space will not permit us to

discuss the technic of the latter in detail in this publication, but any experienced surgeon should have very little difficulty in mastering it. In fact we consider examination of the pelvic organs of the female by this method as being less difficult than an ordinary cystoscopic examination.

We use a general or spinal anesthetic usually. The operation can be done under local anesthesia if heavy doses of preliminary medication are given, but it is difficult to avoid some pain as manipulation is carried out under local.

After the peritoneal cavity is inflated, the peritoneoscope is introduced essentially by the technic previously described by Ruddock[2] except that we introduce it through the middle of the rectus muscle (usually the left) about one inch above the level of the umbilicus. (Fig. 9.) We do this because of the length of the peritoneoscope. Otherwise the lens of the instrument may extend too far into the pelvis and interfere with proper visualization.

If visualization of the pelvic structures indicates a continuation of the operation, a match-head sized nick is made in the skin at a point approximately 1 to 1½ cm. above the superior border of the symphysis (unless there is marked uterine prolapse indicating a higher suspension) and about 3 to 3½ cm. lateral to the midline in the left or right hypogastric region depending upon which round ligament is to be suspended first. Then the knife-edged point of the specially designed round ligament needle (Fig. 4) threaded with a long strong silk suture is passed directly through the nick in the skin and through the abdominal wall structures. The tip of the needle is easily seen through the peritoneoscope as it passes through the peritoneum and should be watched as it enters the peritoneal cavity. It is perhaps best to keep the needle point in the visual field from then on until it is withdrawn and the point is, of course, kept well away from bladder and bowel. We have experienced no difficulty in our cases in feeling perfect security in the handling of the needle.

The needle is worked downward on its curves to the point necessary, depending upon the thickness of the abdominal wall,
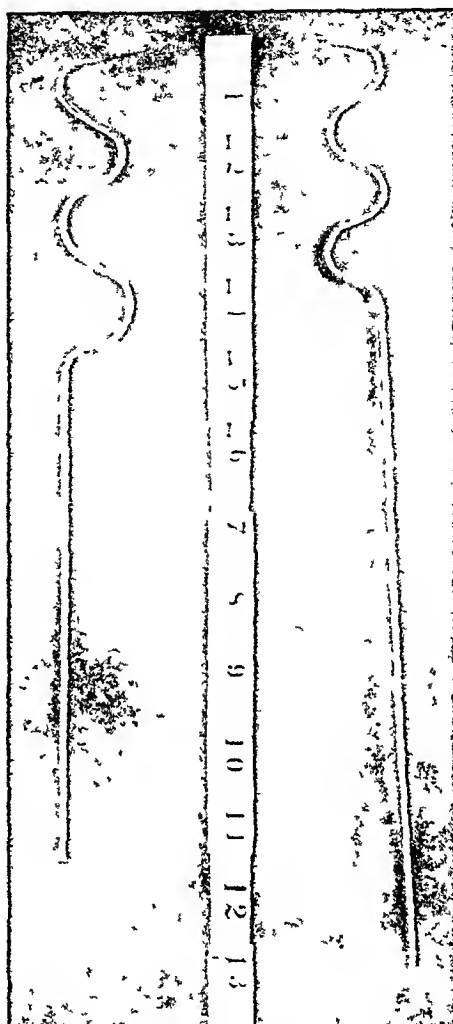
Fig. 8. Shows the different sizes of the round ligament suspension needle. The needle is made of spring steel. It has an eye in the knife-edge at the tip. As described under *Technic*, the curves are in the needle to facilitate intra-abdominal manipulation of the needle tip, with a minimum of trauma to the abdominal wall, the latter falling into the curves in any position in which the needle is manipulated. In subsequent models of the needle, we have adopted a handle which is flat and wide at the end with a marker to designate the side of the handle which faces in the same direction as the tip of the needle. The smaller size needle is sufficiently large for all except the thickest abdominal walls.

and passed just under the round ligament at the point selected. The curved shaft of the needle is then worked back through the

abdominal wall with the round ligament resting in the apex of the first (needle point) curve. At the point where the proximal

FIG. 9. This photograph was selected as showing the rather typical appearance of the abdomen seven days post-operatively. In this patient the nick in the skin at point 4 was enlarged slightly to facilitate tying the suture securely down on the anterior rectus sheath. It was not necessary to take a stitch in the skin at this point, however, and it is rarely necessary to enlarge the original nick at all. In this patient the round ligaments were suspended somewhat higher on the abdominal wall than usual since considerable prolapse of the uterus was present.

part of the distal or "first" curve in which the ligament is resting reaches the abdominal wall, the shaft of the needle is depressed and the point of the needle directed out through the abdominal wall structures, namely, peritoneum, muscles and fascia, to the skin. As the skin bulges to the point of the needle, a small nick is made in the skin with a scalpel at this site. One strand of the suture which is then presenting itself through the needle eye is grasped with a small hemostat and its free end drawn out through the puncture wound through which the point of the needle has emerged from the peritoneal cavity. The assistant has retained the other end of the suture at the site through which the needle point was introduced into the cavity. (Fig. 5.) The

needle tip is then withdrawn through the site where it was originally introduced and freed from the suture which is now resting
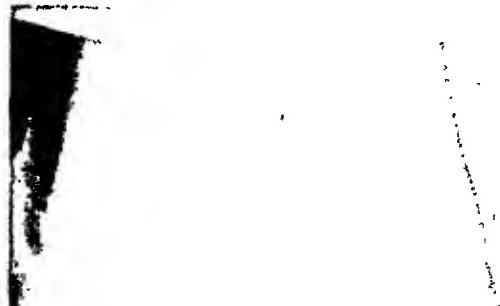
FIG. 10. This photograph shows the typical essential absence of scars three months postoperatively.

beneath the round ligament through the rectus and its fascia just as in the Olshausen procedure. The tip of a mosquito hemostat is now introduced through the original nick in the skin, tunnelled next to the anterior sheath of the rectus until the tip of the hemostat emerges from the second puncture opening in the skin. The strand of the suture emerging from the latter opening is then pulled back through the original puncture wound in the skin by the small hemostat. The suture is then tied with tension over the fascia as in the original Olshausen procedure. (Fig. 6.) While the operator is placing these ties in position, the assistant should observe through the peritoneoscope to insure that a snug approximation is procured. (Fig. 7.) *It is essential that the stitch be tied tightly* with the ligament in very close approximation with the abdominal wall structures. The stitch must cause a necrosis of all the tissues within it because thereby, as described by Graves and Olshausen, a firm fibrous band seals together all the structures enclosed in the stitch. (Fig. 1.)

The curves in the needle facilitate intra-abdominal manipulation of it. (Fig. 8.) By resting the abdominal wall tissues in the proper curve, one may manipulate the needle into any desired intra-abdominal position without undue trauma to the abdominal wall. A straight needle shaft would not permit such atraumatic manipu-

lation in the majority of instances since the abdominal wall tissues would be distorted and traumatized instead of "sliding" into the curve in which they rest with the needle described as intra-abdominal manipulation is carried out.

The first part of the procedure being completed, the same routine is carried out on the other side of the abdomen and the opposite round ligament secured in the same manner as the first. After final peritoneoscopic inspection, the air is permitted to escape from the abdominal cavity and the peritoneoscopic apparatus removed.

We place one stitch or skin clip in the skin at the puncture site through which the peritoneoscope was passed. One does not place stitches in the nicked areas in the hypogastric regions.

The entire operative procedure can be carried out easily by an experienced operator in fifteen minutes in properly selected cases.*

* We have performed this operation upon five additional patients since submitting the above paper for publication. These few cases, however, are not exactly indicative of the frequency with which the operation properly can be performed on an active service, since other investigative procedures and heavy operating schedules have interfered with our collection of suitable clinical material.

We have been able to follow about one-half of our

SUMMARY

We present a new technic for carrying out the Olshausen type of suspension of the uterus, by use of the peritoneoscope and a special needle.

Since the technic does not require open abdominal incision, we permit the patients to become ambulatory on the second or third postoperative day if they choose when perineorrhaphy has not been done.

Since there is no necessity for more than twenty-four to forty-eight hours hospitalization, an appreciable economic saving is offered the patient.

The operation has been done only in those instances in which no intra-abdominal work other than suspension of the uterus was needed.

REFERENCES

1. GRAVES, WILLIAM P. Gynecology. Philadelphia, 1924. W. B. Saunders Company.
2. RUDDOCK, JOHN C. Peritoneoscopy. *Surg., Gynec. & Obst.*, 65: 623, 1937.

patients postoperatively. In no instance has there been a recurrence of the retroversion over the period of time extending back through 1939, this being the year we first performed the procedure upon humans.
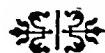
THE DIAGNOSIS OF UTERINE RUPTURE*

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MANY authors consider uterine rupture during pregnancy or labor to be the most serious complication in obstetrics. Although great attention has been paid to this problem, and although all symptoms of threatened and actual rupture are given in textbooks, there are many cases in which the diagnosis of uterine rupture meets with difficulties.

Reviewing the material of the Department of Obstetrics of the Hadassah University Hospital for ten years (1929 to 1938) it will be seen that the determination of the moment of rupture is of great importance for the selection of the best method of intervention. The prognosis for the mother is less favorable when a uterine rupture is diagnosed long after it has occurred or when the rupture is diagnosed after delivery of the child. The results for the mother are much better when the child is delivered through the abdominal incision made for a subsequent *extirpatio uteri*, than when the uterus is removed only after the child has been delivered per vagina.

In our Department of Obstetrics we had during a period of ten years (1929 to 1938) thirteen cases of uterine rupture among a total of 9,079 deliveries, i.e., an incidence of 1:698 or 0.14 per cent. In the statistics reported in the literature we find great differences regarding the frequency of uterine rupture. Stoeckel[1] gives a rate of from 1:235 to 1:6100. Kupferberg[2] reviewing a period of twenty years, reports twenty-four cases or 0.1 per cent. Wlassow[3] reports eight cases among 34,650 deliveries, i.e., an incidence of 1:4331, or 0.023 per cent. Sheldon[4] reports twenty-six cases among 47,554 deliveries or 0.05 per cent (1:1839).

The widespread performance of cesarean section and the indiscriminate use of pituitary extracts during labor are responsible for a great number of cases of *ruptura uteri* (DeLee[5]). This was confirmed by Kupferberg[2] who, reviewing the cases of uterine rupture during a period of twenty years, found a rate of 0.3 per cent in the first twelve years, while during the last eight years this rate rose to 3 per cent. We are unable to confirm this fact from our material. During the first five years (1929 to 1933) we had seven cases and during the last five years (1934 to 1938) six cases, while the number of deliveries during the second half was almost twice that of the first (1929 to 1933, 3,446 deliveries; 1934 to 1938, 5,633).

Uterine rupture occurs more frequently in multiparae and the danger of rupture increases with the number of deliveries. DeLee[5] thinks that the rate is eight times higher in multiparae than in primiparae. Hammerschlag[6] found 95 per cent of uterine rupture in multiparae. Sheldon[4] found only two in primiparae among a total of twenty-six cases. All our cases of uterine rupture were in multiparae.

TABLE I

CASES OF UTERINE RUPTURE IN MULTIPARAE

No. of Deliveries	No. of Cases
2	1
3	2
4	2
6	2
8	1
9	2
10	2
Multiparae ?	1

As is well known the prognosis of uterine rupture is very serious to both mother and child. Out of thirteen cases we had six cases of maternal mortality or a mortality rate of 46.1 per cent. The mortality rate varies from 40 to 60 per cent, according to different authors. (Table II.)

* From the Department of Obstetrics and Gynecology, Hadassah University Hospital, Jerusalem.

TABLE II
Per Cent

Hadassah Univ. Hosp.	46.1	
DeLee[5]	40	
Hammerschlag[6]	70	complete rupture
	50	incomplete rupture
Carton[7]	44	
Berkley, Bonney[8]	50 to 60	
Kupferberg[2]	45.8	
Sheldon[4]	42.3	

Fetal mortality reaches 90 per cent or more. We had 100 per cent fetal mortality. Only Sheldon gives a rate of 42 per cent.

In our material we had twelve cases of complete and one case of incomplete uterine rupture. Of our thirteen cases, eight cases were spontaneous uterine ruptures, three were violent ruptures and two on the border between violent and spontaneous, in connection with not very careful use of pituitary extracts.

Operations were performed in eleven cases (extirpatio or amputatio uteri supravaginalis). One patient died before the operation of acute anemia. One patient was not operated upon (the diagnosis of incomplete uterine rupture was made only one day after spontaneous delivery—the patient recovered).

Of the eleven patients operated upon, five died. Two of these were brought to the hospital in a severe general condition with all signs of uterine rupture (one died twenty minutes, the other forty-five minutes after operation). Of the other three fatal cases, one patient died five hours, another six hours after operation; the third died of embolus five days after operation.

In seven patients the uterine rupture occurred in the hospital, only one of whom died. The other six patients were admitted to the hospital with symptoms of threatened or actual uterine rupture; of these five died. From the above we may conclude that early diagnosis and operation are of utmost importance.

We have already mentioned that the prognosis is much better when the uterus is extirpated without first delivering the child per vias naturales. In six cases in which the child was delivered through the abdominal incision, only one ended fatally, while in the other seven cases, in which the child was first delivered per vagina and operation followed, five patients died.

The obstetric interventions in the last mentioned seven cases were: two embryotomies (neglected shoulder presentation), three forceps, one perforatio capitis, one combined version (suspected accidental hemorrhage). The operations were performed when the diagnosis of uterine rupture was not clear or when the presenting part was fixed on the pelvic floor.

In all textbooks the symptoms of threatened and actual uterine rupture are given in detail. Unfortunately, many of these symptoms are not observed. The theory of Bundle and his picture of uterine rupture are confirmed in the literature in a great number of cases. Nevertheless, there are cases in which the rupture occurred in connection with pathological changes in the uterine tissue, and the clinical picture obtained is thus completely different. Of the eight cases reported by Wlassow,[8] the symptoms according to Bundle were present only in one case; in the other seven cases the classical symptoms of threatened uterine rupture were absent. The same fact is reported by Vitzka.[9] One of our cases belongs also to this group.

CASE 1. No. 44334, the patient, age thirty-five, was pregnant for the tenth time. According to the husband, the patient continued to work at home even after labor pains had started. In the middle of the work the patient fell down and fainted. When admitted to the hospital, the fetal heart sounds were not heard (in the differential diagnosis both uterine rupture and accidental hemorrhage had to be considered). Because of a five-finger dilatation we decided upon manual dilatation and combined version with manual extraction. The placenta was separated immediately after extraction of the child. This confirmed the diagnosis of accidental hemorrhage. Internal examination revealed uterine rupture on the left side. The patient died forty-five minutes after delivery before operation was begun.

In this case the fetus remained in the uterus, so that, besides the internal hemor-

rhage, no other signs of uterine rupture were present. Were it not for the tempting five fingers' dilatation, we would have operated upon this patient because laparotomy is indicated in both uterine rupture and accidental hemorrhage. We are unable to overcome the suspicion that the first complaint was accidental hemorrhage, and that the uterine rupture took place during the combined version.

Also in those cases in which uterine rupture was preceded by the symptoms given by Bundle, there were still many signs missing and the picture was confusing. The obstetric interventions made because of a not very clear diagnosis only brought the fatal outcome of the case nearer. The symptoms described by Bundle were present only in four cases. In these four cases all symptoms were present, while in the eight remaining cases there were deviations from the typical picture:

In one case (No. 40301) the patient, forty-two years old, delivered a dead child. A short time before delivery she complained of pain in the left side. This pain did not raise any suspicion of uterine rupture. Only after twenty-four hours, when an internal examination was made, an incomplete uterine rupture was detected at the height of the uteri internum. Since the patient felt well, a conservative attitude was taken. The patient suffered from parametritis and left the hospital after three months completely recovered.

In two other cases (No. 32866 and No. 10518) the rupture occurred a short time before delivery. In both cases the head was low and visible through the rima pudendi. Since there were fruitless pains outlet forceps was performed, and only after delivery did all pernicious symptoms of uterine hemorrhage caused by rupture appear. This fact was noted by DeLee[5] who says: "If the child has not been expelled into the abdominal cavity the pains may continue, though weaker, and they may, though rarely, suffice to deliver the child." This has also been noted by Hammerschlag.[6]

In two cases of neglected shoulder presentation in which some symptoms of threatened uterine rupture were present, it is possible that the rupture took place during embryotomy.

In one case (No. 29311) in which the child was delivered by high forceps, a violent uterine rupture may have occurred.

In the remaining two cases in which pituitary extract was used, the typical picture of rupture, according to Bundle's description, had not enough time to develop.

Although better results are obtained when the extirpation of the uterus is not preceded by any obstetrical intervention, we are, in many cases, obliged to intervene in one or another form. This occurs in cases in which the presenting part is low and the diagnosis of uterine rupture not yet clear (absence of signs of internal hemorrhage and persisting pains), in cases in which the diagnosis oscillates between uterine rupture and accidental hemorrhage, and a sufficient dilatation exists for termination of labor by an obstetrical intervention (No. 44334, mentioned above), and naturally in cases in which the diagnosis is made after obstetric intervention (violent rupture following high forceps and shoulder presentation).

SUMMARY

1. In the Obstetrical Department of the Hadassah University Hospital, Jerusalem, there were, during a period of ten years thirteen cases of uterine rupture among a total of 9,079 deliveries, i.e., an incidence of 1:698 or 0.14 per cent.

2. In spite of statistical data in the literature to the contrary, the number of cases decreased by half during the second part of the decade.

3. All thirteen cases occurred in multiparae.

4. Maternal mortality was 46.1 per cent (6:13). Fetal mortality 100 per cent.

5. We had eight cases of spontaneous rupture, three of violent rupture and two cases in connection with a not very careful use of pituitary extract.

6. Eleven patients were operated upon (uterine extirpation or amputation). One patient died before operation; one was not operated upon because the rupture was not diagnosed (patient recovered).

7. The uterine rupture took place in the hospital in seven patients, one of whom died. The other six patients were admitted to the hospital with signs of actual or threatened rupture; of these, five died.

8. The typical picture of uterine rupture, as given by Bundle, was present only in four cases.

9. In six instances operation was performed with no preceding obstetrical intervention; one of these patients died. In seven cases laparotomy was performed after obstetric intervention; five of these patients died. It thus follows that the prognosis is much better when laparotomy is not preceded by any obstetrical interven-tion. Unfortunately, in some cases, obstetrical intervention is unavoidable.

I am indebted to Prof. O. Zondek for permission to use the material of the Department.

REFERENCES

1. STOECKEL, W. Lehrbuch der Geburtshilfe. P. 521. Jena, 1930.
2. KUPFERBERG. Zur Uterusruptur. *Zentralbl. f. Gynäk.* 51: 758, 1927.
3. WLASSOW. Die spontan ruptured. Uterus. *Zentralbl. f. Gynäk.*, 58: 1165, 1934.
4. SHELDON. A record of 26 cases of rupture of the uterus. *Am. J. Obst. & Gynec.*, 31: 455, 1936.
5. DeLEE. Principles and Practice of Obstetrics. P. 852. Philadelphia, 1938. W. B. Saunders Co.
6. HAMMERSCHLAG, S. Lehrbuch der operativen Geburt-shilfe. P. 378. Leipzig, 1924.
7. CORTON, G. Notes sur les ruptures uterines ob-serves a la maternite de Hanoi des 1930-1934. *Gynec. et Obst.*, 33: 366, 1936.
8. BERKELEY, BONNEY and MacLEAD. The Abnormal-ity in Obstetrics. P. 240. London, 1938. Arnold.
9. VITZKA, A. B. Spontaneous rupture of the uterus during labour. *J. Obst. & Gynec.*, 127: 9-10, 1937.

PARTIAL GIANT GROWTH*

OPERATIVE REDUCTION IN SIZE OF A FOOT

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MALFORMATIONS which take their origin in a faulty fetal anlage are characterized by their size, shape

Genuine giant growth can implicate the entire body, a body half, one extremity, hand or foot, single fingers or toes. Accord-

Fig. 1. Before operation.

Fig. 2. After operation.

or in that the number of the component parts varies from the normal. In the first group congenital giant growth plays a modest rôle commensurate with its rarity.

One differentiates between genuine and false giant growth. It is considered genuine when all tissues are equally involved. In false giant growth one tissue is primarily or the only tissue involved. In this group are considered the congenital diffuse lymphangiomas which have been termed congenital elephantiasis by French authors (Kirmisson, Lannelongue).

ingly, one speaks of total or partial giant growth. With a certain regularity it appears that the excessive growth is more abundant the more peripheral the involved part. During the growth period the implicated part may either enlarge proportional to its original oversize or it can increase out of all proportions. In the latter case we speak of monstrosities. In all cases of giant growth one frequently finds abnormalities of the vascular system such as naevi, angiomas, ectasias and occasionally pigmentations.

Giant growth, while considered congenital, has formerly not been considered hereditary. More recently a few cases were observed in which familial appearance was noted. This led to the conviction that one was dealing with a hereditary condition. The difficulties to prove the hereditary nature of this deformity are due to its rarity and its recessive character.

Beyond the general interpretation as faulty primary anlage there are several theories concerning its etiology. Some deal with nervous others with vascular anomalies.

Interference with function and cosmetic considerations determine the surgical indications. If one entire extremity is involved and the growth period not yet consummated, epiphyseal arrest by means of surgery or x-ray is of course the treatment to be contemplated. On the whole, one frequently has to take recourse to maiming procedures, amputations and disarticulations, particularly in dealing with a single enlarged finger or toe. If an entire hand or foot is involved, individual requirements have to be considered. In giant growth of the foot, for instance, we found the removal of the entire fifth metatarsal segment ("ray of the foot") to be a very useful procedure.

A sixteen year old girl whose family history was in no way remarkable complained that it was impossible for her to get a shoe which would fit her right foot. She stated that this foot has always been somewhat wider than the left one and that during adolescence the dis-

FIG. 3. Before operation.   FIG. 4. After operation.

proportion between the two feet increased considerably.

Examination revealed a foot which was markedly developed in width but only slightly longer than the left. In the enlargement soft parts and bones took an equal part. Both legs were equally long and the right calf slightly more developed than the left. All joints showed normal motion and there was no functional defect. As the only other asymmetry the right mammary gland was markedly enlarged, an observation which we have also noted in other cases of partial giant growth.

The patient insisted upon having both feet made the same size. To accomplish this, the removal of the lateral segment was obviously the best way.

Through a dorsolateral incision the fifth toe and metatarsal bone were exarticulated and the lateral part of the cuboid chiseled off, making it even with the base of the fourth metatarsal. The tendon of the peroneus longus muscle was preserved, the tendon of the peroneus brevis, having removed its insertion, was reanchored to the remains of the cuboid. The hypertrophied fatty tissue within reach of the incision as well as the short foot muscles of the fifth metatarsal were excised.

The patient made an uneventful recovery. Several months later she had no difficulty wearing normal foot gear. The patient was followed up well into her adult life. At no time did she complain of a functional disadvantage at the site of the operation.

THE USE OF THE TRANSFIBULAR APPROACH IN ARTHRODESIS OF THE ANKLE JOINT

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THE purpose of this communication is to record the use of a surgical approach to the ankle joint in the performance of arthrodesis of this joint, which has been adopted from an approach advocated by Gatellier[1] and, more recently, by Alldredge[2] for the operative reduction of certain ankle fractures.

Surgical fusion of the ankle joint is employed in the treatment of various destructive arthritides involving that joint, infectious or degenerative in origin; in the reconstruction of severe fractures about or involving the ankle joint, either as a primary or secondary procedure; and for the stabilization and correction of deformities of the ankle region and foot, as in infantile paralysis and certain congenital anomalies. Most operative procedures for securing ankle fusion, whether they be extra-
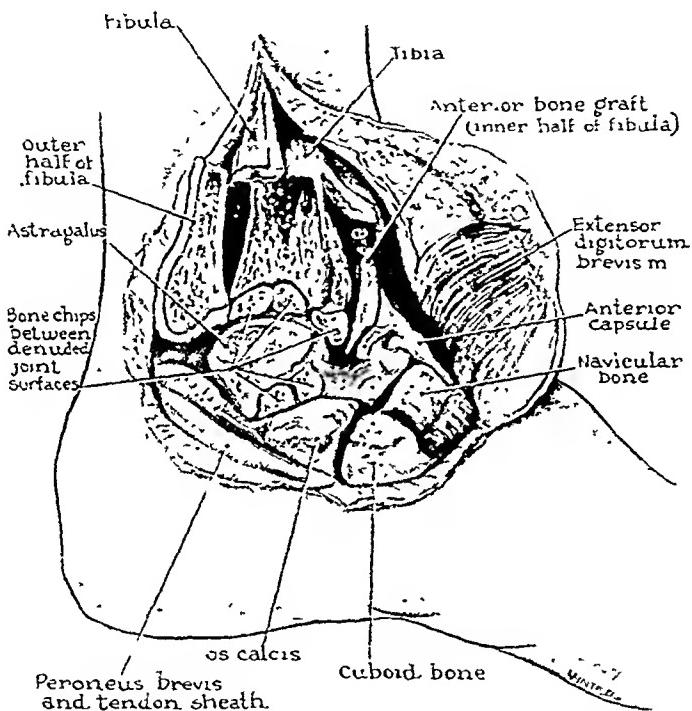
Fig. 1. Illustrating the use of the transfibular approach to the ankle joint, during panarthrodesis of the foot. The fibula has been osteotomized in its lower portion and the distal fragment has been reflected laterally. The subastragalar and midtarsal joints have been exposed through the same incision. The medial half of the reflected fibular fragment has been transplanted to bridge the anterior surface of the ankle joint, while bone chips have been introduced between the denuded articular surfaces. Upon closure, the lateral fibular fragment will be restored to its original position, where it will contact the denuded lateral surfaces of the tibia and astragalus.

articular, intra-articular or combined extra- and intra-articular, utilize either an anterior, posterior, combined anterior and

leaving only its posterior attachments intact. The ankle joint is further exposed, especially anteriorly, by additional soft

Fɪɢ. 2. Anteroposterior and lateral roentgenograms of the foot of a thirty-five-year old male, a few days after panarthrodesis for a paralytic flail foot with valgus deformity, secondary to a traumatic cord lesion.

Fɪɢ. 3. Anteroposterior and lateral roentgenograms of the foot of a forty-five-year old male, a few days after arthrodesis of the false ankle joint following astragalectomy two years previously for a comminuted fracture of the astragalus. The resultant equinovarus deformity had been very disabling. The entire distal fibular fragment was used as a lateral graft to bridge the joint after the latter had been denuded and filled with bone chips.

posterior or lateral approach. All of these approaches present certain inadequacies or undesirable features.

The transfibular approach, utilized by the writer, combines two principles: (1) osteotomy of the fibula as advised by Goldthwait[3] to insure accurate coaptation of all denuded surfaces between the astragalus and ankle mortise, and (2) the approach of Gatellier[1] who exposed the ankle joint by freeing the lower portion of the fibula and turning it downward, the external lateral ligaments acting as a hinge.

Operative Procedure. The skin incision runs along the posterior border of the lower 10 cm. (4 inches) of the fibula and, just below the tip of the external malleolus, swings forward to end over the cuboid bone. The peroneal tendons are exposed and retracted posteriorly or divided. The fibula is osteotomized about 7.5 cm. (3 inches) above the tip of the malleolus and this lower fragment is reflected laterally,

tissue stripping. When a panarthrodesis is to be performed, the soft tissues are dissected from the bone on the lateral surface of the foot to expose the subastragalar, calcaneocuboid and astragaloscaphoid articulations. (Fig. 1.)

Following denudation of the joint surfaces the reflected distal fibular fragment is returned to its original position. The writer has pursued the following technic: After denudation of the articular cartilage from the joint surfaces and the insertion of numerous bone chips, the reflected fibular fragment is split longitudinally, the medial half being used as a free bone graft across the ankle joint anteriorly, and the lateral half being reapplied to the denuded lateral surfaces of the tibia and astragalus. (Fig. 1.) When the subastragalar joint is

also being ankylosed, the lateral fibular portion may be freed further and shifted downward to span both the ankle and

CONCLUSIONS

The transfibular approach simplifies the exposure of the ankle joint for arthrodesing
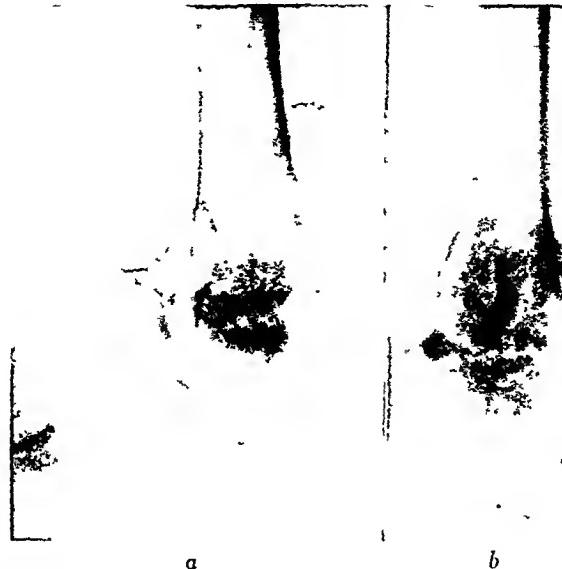
FIG. 4. *a*, lateral roentgenogram of the hindfoot of a seventeen-year old male, three months after panarthrodesis for a paralytic calcaneovalgus deformity, following acute anterior poliomyelitis. *b*, lateral roentgenogram of the hindfoot of a fourteen-year old male, three months after panarthrodesis for a severe congenital equinovarus deformity with disturbed distal tibial epiphyseal growth.

subastragalar joints. The attachment of the fibular fragment is secured by heavy catgut sutures. The position of the foot and the need for correction of any residual deformity by manipulation or cast-wedging are determined by postoperative roentgenographic study.

The transfibular approach has been employed by the writer for the surgical fusion of the ankle joint in five cases. (Figs. 2, 3, 4*a* and 4*b*.) It should not be used in young subjects, except in selected cases (Fig. 4*b*), because of the danger of disturbing normal epiphyseal growth.

purposes by obviating the necessity for wide soft-tissue dissection and distorsion of the foot, and it assures complete bony contact of all of the denuded articular surfaces.

REFERENCES

1. GATELLIER, J. The juxtoretroperoneal route in the operative treatment of fracture of the malleolus with posterior marginal fragment. *Surg., Gynec. & Obst.*, 52: 67–70, 1931.
2. ALLDREDGE, R. H. Diastasis of the distal tibiofibular joint and associated lesions. *J. A. M. A.*, 115: 2136–2140, 1940.
3. GOLDTHWAIT, J. E. An operation for stiffening of the ankle joint in infantile paralysis. *Am. J. Ortho. Surg.*, 5: 271–275, 1908.

PATHOGENESIS OF ARTHRITIS FOLLOWING THE INTRAVENOUS INJECTION OF STAPHYLOCOCCI IN THE ADULT RABBIT*

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THE incidence of staphylococci as the causative agent of pyogenic infections of bones and joints is high. The pathogenesis of these lesions is not always clear either from an experimental or clinical standpoint.

Osteomyelitis usually occurs in young rabbits following the intravenous injection of Staphylococcus aureus. Experimental studies[1,2] show that when this organism is given intravenously to young rabbits it localizes in the capillaries of the metaphysis of the long bones and abscesses subsequently develop. The infection gradually extends to the adjacent tissues. Thompson and Dubos[3] observed that the infection extended from the end of the long bones into the joints in only eight out of forty-seven cases of osteomyelitis. Kistler[4] found that all healthy growing rabbits receiving living cultures of staphylococci intravenously and surviving the septicemia for more than two days, develop marked exudative arthritis in one or more joints with destruction of the articular cartilage and subchondral bone. Lexer[5] states that adult rabbits develop a suppurative arthritis following the intravenous injection of staphylococci. From the studies of Kistler, Lexer and Thompson and Dubos it appears that both osteomyelitis and arthritis may occur in growing and adult rabbits following the intravenous injection of staphylococci.

The present paper is a study of the pathogenesis of purulent arthritis in the adult rabbit following the intravenous inoculation of a broth culture of Staphylococcus aureus. The articular lesions are observed in three groups of rabbits: First, in the normal; second, animals previously immunized with staphylococcic toxin; and third, rabbits given staphylococcic antitoxin.

The larger joints are observed macroscopically. Roentgenograms are made at frequent intervals. Bacteriological and pathological examinations are made on the joints after they have been infected for different periods of time.

The arthritic lesion following the intravenous injection of a broth culture of Staphylococcus aureus is compared with the local lesion that follows the intra-articular inoculation of the knee joints with the same bacterium.

EXPERIMENTAL

Rabbits vary in their susceptibility to staphylococci and staphylococcic toxin. This is thought to be the result of natural immunity. In view of this, the following procedure is carried out to determine the approximate lethal dose of the culture of Staphylococcus aureus used in the following three groups of rabbits: Group 1, normal rabbits; Group 2, those immunized with staphylococcic toxin; Group 3, animals given the same quantity of a broth culture of Staphylococcus aureus and the period of survival is observed. The strain of staphylococci used in these experiments was isolated from a patient who died with agranulocytic angina. It has been used in other experiments.[6-7]

Nine rabbits in Group 2 are given twelve intravenous injections of staphylococcic toxin over a period of one month. The day following the last injection the

animals are given 4 cc. of a twenty-four-hour broth culture of staphylococci. Five rabbits in Group 3 are injected with 1,750 units of staphylococcic antitoxin* and four hours later they are injected with 4 cc. of the same bacterial suspension. Five rabbits in Group 1 are used for the controls. The following data show the time of death of the rabbits in the three groups:

Immunized with Staphylococcic Toxin		Given Staphylococcic Antitoxin		Normal	
No.	Results	No.	Results	No.	Results
100	Killed after 26 days	111	Died after 20 hrs.	112	Died after 20 hrs.
102	Died after 60 days	113	Died after 92 hrs.	114	Died after 56 hrs.
103	Died after 8 days	115	Died after 27 hrs.	116	Died after 20 hrs.
104	Died after 14 days	117	Died after 56 hrs.	118	Died after 20 hrs.
105	Died after 11 days	119	Died after 127 hrs.	120	Died after 20 hrs.
106	Died after 11 days				
108	Killed after 28 days				
109	Died after 96 hrs.				

The period of survival of the rabbits in the three groups is too short to compare the frequency of the development of joint lesions. It appears advisable in subsequent experiments to compare the lesions in rabbits immunized with staphylococcic toxin and given the same number of staphylococci with one group of normal animals and the pathological changes in rabbits given staphylococcic antitoxin and a different amount of the inoculum with another group of normal animals.

ARTHRITIS IN THE NORMAL RABBIT FOLLOWING THE INTRAVENOUS INJECTION OF A BROTH CULTURE OF STAPHYLOCOCCUS AUREUS

Four adult rabbits were given a single intravenous injection of a broth culture of

* The antitoxin was supplied by Lederle Laboratories.

Staphylococcus aureus. Two of these died twenty-four hours later. A third died after forty-eight hours and the fourth was moribund at this time and was killed.

A bacteriological examination was made on one of the two rabbits that died after twenty-four hours and on the one killed after forty-eight hours. A small amount of blood tinged fluid was present in the left knee of the former and in both knee joints of the latter. Gram-positive cocci were cultured from this fluid. This bacterium gives the same fermentation reaction as the organism isolated from the heart's blood, and also the same as that of the original inoculum.

Six normal adult rabbits were given 2.0 cc. of the same culture of staphylococci. One animal died after twenty-four hours and two after forty-eight hours. Two other rabbits developed a purulent arthritis, one in both knees and the other in only the right knee. One rabbit was normal after thirty days and was discarded. The animal with arthritis in the right knee was observed over a period of approximately six months during which time roentgenograms were made at frequent intervals. Two blood cultures taken during this period were sterile.

A second group of five rabbits was given a smaller number of staphylococci on each of the following days: first, eighth, nineth and twelfth. One rabbit in this group died on the seventeenth and another on the twentieth day of the experiment. Neither of these two animals showed any gross pathological changes in the larger joints. Three rabbits were normal after thirty days and were discarded. A blood culture was sterile from one of these when they were discarded.

The above observations show that staphylococci, when injected intravenously reached the joint cavity within a period of twenty-four hours. The blood stream may subsequently become sterile and the rabbit live for six months with an active lesion in the joints. When the inoculum is small, either the bacteria do not localize in the

joints' cavities or the local resistance is sufficient to prevent the production of a lesion.

It is interesting to observe the absence of osteomyelitis in any of the fifteen rabbits used in these experiments.

ARTHRITIS IN RABBITS IMMUNIZED WITH STAPHYLOCOCCIC TOXIN AND GIVEN A BROTH CULTURE OF STAPHYLOCOCCUS AUREUS INTRAVENOUSLY

Five rabbits were immunized with staphylococcus toxin. Three series of intravenous injections of the toxin were given during a period of approximately five months. Six days after the last injection of the toxin the animals were given intravenously a broth culture of staphylococci. One rabbit died four days later and another developed purulent arthritis in the left elbow. This joint was macroscopically normal forty-five days following the inoculation of the bacteria. Roentgenograms at this time showed only a slight periarticular swelling. Three of the rabbits did not show any lesion during a period of thirty days.

Five normal rabbits were used as controls. Every animal died within forty-eight hours after the bacteria were injected.

A second group of eight rabbits were immunized over a period of one month and then given intravenously a broth culture of staphylococci. One animal died in less than four days. Seven lived for eight days or longer and three of these developed macroscopic arthritis in one or more of the larger joints. Two of the rabbits with arthritis were killed twenty-six days following the inoculation of the bacteria. Both knees, the left elbow and the right shoulder in one rabbit were filled with caseous material. Smears of this exudate show leucocytes and Gram-positive cocci which are considered to be staphylococci. The third rabbit with arthritis was killed after approximately two months. A smear and culture from the exudate in one of the knee joints showed the same bacterium as described above. The culture from the heart's blood was sterile. The joint lesions were followed at frequent intervals with roentgenograms and pathological studies were subsequently made on the tissues.

Five normal rabbits in the control group were given the same volume of the broth culture of staphylococci. All were dead in less than fifty-six hours.

The roentgenological and pathological changes in this group of rabbits given a series of injections of staphylococcic toxin are the same as those that occur in normal rabbits following the intravenous injection of staphylococci.

ARTHRITIS IN RABBITS GIVEN STAPHYLOCOCCIC ANTITOXIN AND BROTH CULTURES OF STAPHYLOCOCCUS AUREUS

The effect of staphylococcic antitoxin on rabbits given broth cultures of staphylococcus aureus has been reported.[8] The length of the survival period following the intravenous injection of staphylococci is influenced by the amount of antitoxin given and the time elapsing between the injections of the organisms and the antiserum.

Seven rabbits were given multiple injections of staphylococcic antitoxin and then a single intravenous injection of a broth culture of staphylococci. One animal died twenty-four hours later and another lived for seven days. Four rabbits developed purulent arthritis. One was normal thirty days after the inoculation and was discarded. A rabbit with arthritis in the right and left elbow was killed on the fourth day of the experiment. Another with a swelling of each knee and the right elbow was killed on the eighteenth day. Smears and cultures from the material in the joints of the latter rabbit showed a Gram-positive coccus which is considered to be a staphylococcus. A culture of the heart's blood was sterile. Roentgenograms and pathological studies were made on these rabbits.

Six rabbits were in the control group. All were dead in less than forty-five hours following the injection of the bacteria.

A second group of four rabbits was given multiple injections of staphylococcic antitoxin and two inoculations of a broth culture of Staphylococcus aureus on consecutive days. All the animals developed purulent arthritis. Smears and cultures from the material in the joints showed a Gram-positive coccus which was considered to be a staphylococcus. The blood from the heart of two rabbits taken on the tenth and thirteenth days of the experiment was sterile. A staphylococcus was isolated from the blood of the third rabbit on the fourteenth day following the injection of the bacteria.

Four animals in the control group receiving the same amount of the broth culture of staphylococci were either dead or moribund forty-eight hours later.

Lesions developed in the joints following the intravenous injection of staphylococcus in the rabbits give staphylococcic antitoxin the same as in the nonimmune rabbits. No primary lesions were observed in the bones.

CLINICAL OBSERVATIONS

The macroscopic changes are essentially the same in these three groups of rabbits. The number of infected joints vary. The larger joints in the extremities begin to swell approximately five days following the intravenous injection of the broth culture of staphylococci. The rate at which the swelling progresses varies in different rabbits. The skin over the swollen joints does not appear abnormal.

The swelling is localized to the joints in the early stages of the infection. As the inflammation progresses the contour of the joints frequently becomes irregular and the adjacent tissues swell. The joints are rubbery in consistency when they reach their maximum size. The bones in some of the joints can be moved at this time and frequently a grating sensation is noted. This grating is the result of erosions in the articular cartilage. While the joints are swollen the rabbits attempt to keep the extremity at rest. The swelling usually increases for two to three months and then

gradually decreases during the following two to three months. The joints usually remain larger than normal.

Three rabbits with arthritis were followed for approximately seven months. The function of the knee joints in two of these was apparently only slightly impaired after six months. The amount of movement and the grating sensation obtained when the articular surfaces of opposite bones are rotated on each other decreases considerably by the fifth to the sixth months.

The rabbits frequently lost weight following the injection of staphylococci especially those animals with multiple joint involvement. The weight is usually also slightly below normal in the rabbits in which only one joint is infected over a long period.

ARTHRITIS IN THE NORMAL ADULT RABBIT FOLLOWING THE INTRA-ARTICULAR INJECTION OF STAPHYLOCOCCI

Macroscopically the lesions in the knee following the intra-articular injection of staphylococci are similar to the process that follows the intravenous inoculation of the same organism. The bacteria are injected through a No. 27 gauge needle into the cavity of the knee joints. The needle is passed through the petella. The swelling in the joints and the adjacent tissues are more marked in this group of rabbits than in those animals given the bacteria intravenously. Blood cultures from five of the rabbits taken eight days after the intra-articular injection of staphylococci were sterile. Bacteria considered as staphylococci were isolated from the exudate in the knee joints of two of these animals.

ROENTGENOLOGICAL EXAMINATIONS*

The roentgenological changes observed in the joints following the intravenous

inoculation of broth cultures of staphylococci, like the pathological vary slightly in the different animals. The general process, however, is always the same. During the first two to three weeks the roentgenograms show only periarticular swelling. After this time the articular surfaces of the tibia and femur appear slightly rough. This change progresses in some of the rabbits until there are small focal areas of bone destruction which extend down into the epiphysis. Accompanying this chance is a condensation of the ends of the bones. Some of the joints after two to three months show an atrophy of the periarticular tissues, a decrease in the space between the articular surfaces of the bones and a proliferative reaction. A few of the animals with extensive involvement of a joint for six months or longer show some evidence of what appears to be a beginning ankylosis. (Figs. 1, 2 and 3.)

Periarticular swelling is the first change observed in the posterior extremities of rabbits following the intra-articular injection of broth cultures of staphylococci. A rough articular surface subsequently develops. It progresses until an extensive destruction of the adjacent bones occur with a diminution in the space between the femur and tibia. Proliferation of bone and ankylosis of the knee joint may develop after three to four months.

There is nothing in any of the roentgenograms to suggest either a primary osteomyelitis, epiphysitis or periostitis in the rabbits receiving the broth cultures of staphylococci either intravenously or directly into the joint cavity.

The pathological changes which occur in the knee joints of rabbits receiving broth cultures of staphylococci intra-articularly are similar to the lesions that develop in the joints following the intravenous injection of the same organism. The extent of injury is much greater, however, in the former group. Calcification and ankylosis also occur more frequently in the group of rabbits given the bacteria directly into the joint space.

PATHOLOGICAL STUDY

Swelling of the larger joints is usually detected three to five days following the intravenous injection of staphylococci. This swelling gradually increases for approximately two months. The joints at this time are rubbery in consistency. The swelling slowly decreases. The knee joints of the animals that live for three months or longer apparently never returned to their normal size.

Some of the joints examined during the first forty-eight hours contain a small amount of blood-tinged fluid. Staphylococci are frequently demonstrated in the cultures, the smears and in the histological sections removed from these early lesions. During the first forty-eight hours the periarticular tissues may become edematous. Abscesses frequently occur in the muscles and viscera. The earliest histological change observed in any joint is a perivascular infiltration of leucocytes in the fat pads in the knee. This animal died seventeen hours after the intravenous injection of staphylococci. The earliest macroscopic lesion observed in a joint occurred in the right knee of a rabbit forty-eight hours after the intravenous inoculation of the bacteria. There was a small amount of bloody fluid in this joint; the fat pads were hemorrhagic. Polymorphonuclear leucocytes and endothelial-like cells infiltrate the synovial membrane and a purulent exudate was present on the surface. The synovial cells were fragmented and pyknotic. The capsule of the joint was edematous. It was infiltrated with red blood cells, polymorphonuclear leucocytes and mononuclear cells. A section of this capsule showed Gram-positive cocci in the lumen and in the wall of some of the capillaries. Groups of similar bacteria were present in the interstitial tissue and between the cells in the areas of the cellular reaction. Gram-positive cocci were present in the cytoplasm and apparently were sticking to the surface of leucocytes and other cells which resemble those lining the

synovial membrane. These bacteria are considered to be staphylococci. Many of the tissue cells in the area of the bacteria showed evidences of injury.

this time the contents of many of the joints had dissected outward along the tendon sheaths and lay in large masses between groups of muscles.

FIG. 1. The roentgenograms are made on the following days after the staphylococci are injected intravenously. From left to right, control showing left knee. Right knee after 130, 260 and 327 days. After 130 days there is beginning destruction of the medial cartilage. The intercondylar groove of the femur is deeper than normal. In the third picture there is complete destruction of the medial cartilage. The articular surfaces of the femur and tibia are eroded. After 327 days the erosion has progressed. There is some bone destruction and beginning bony ankylosis.

FIG. 2. The roentgenograms are made on the following days after the staphylococci are injected intravenously. From left to right, 18, 25, 123 and 186 days. There is no definite pathological change observed after eighteen days; however, on the twenty-fifth day there is some narrowing of the joint space and a beginning erosion of the intercondylar groove. The outer margin of the medial condyle of the femur shows some erosion. The processes are progressing and on the 123rd day the medial cartilage is almost completely destroyed. There is some sclerosis of the bone above the articular areas involved. There is a further exaggeration of the above processes on the 186th day. The decalcification present at this time may have resulted from disuse of the joint.

The exudate in the joint cavities gradually increased and the capsule became more diffusely infiltrated with inflammatory cells. After approximately one month the joints were filled with a thick, yellowish-gray, caseous material and the synovial membrane was completely destroyed. By

The articular cartilages in the infected joints were smooth and grossly normal during the first ten days of the experiment. They are frequently eroded, however, by the twenty-sixth day. This lesion apparently served as a route for the bacteria to reach the epiphysis. Figure 4 shows the

Fig. 3. The roentgenograms are made on the following days after the staphylococci are injected intravenously. From left to right, 35, 89, 117 and 180 days. There is some decalcification about the joint in the first picture. In the second there is beginning erosion of the lateral border of the medial femoral condyle and a deepening of the intercondylar groove. The third shows that the erosion is progressing. There is some destruction of the bone above the intercondylar groove. The joint space is narrower. These pathological processes are progressing as shown by the last plate.
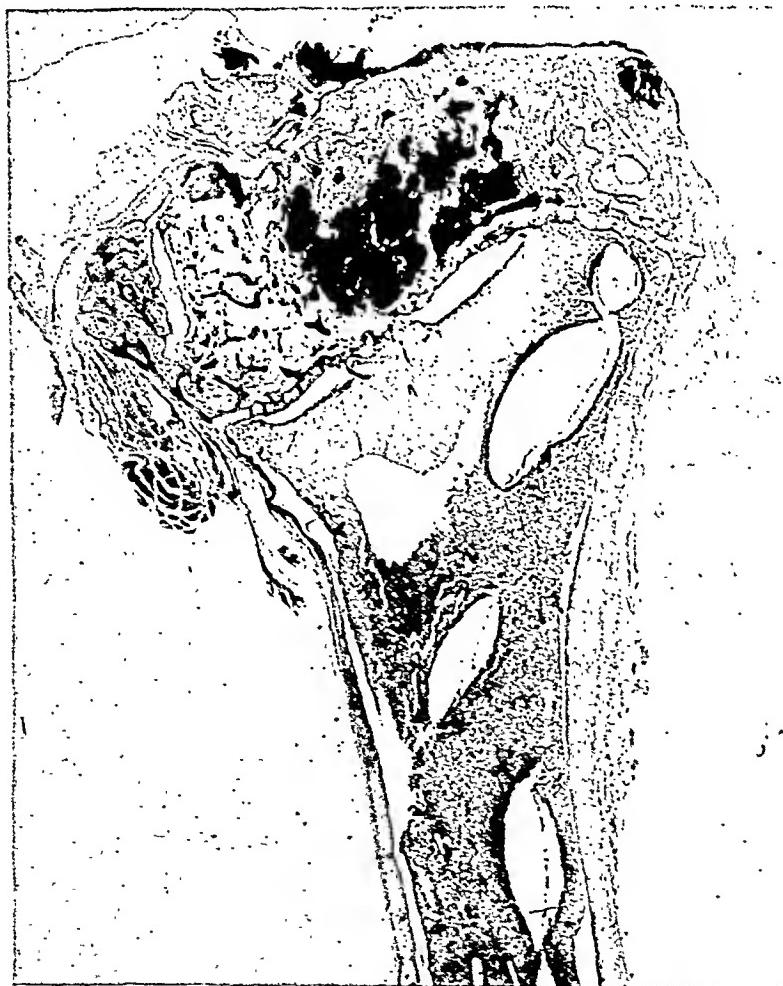
Fig. 4. This rabbit is injected intravenously with a broth culture of staphylococci and killed seventy days later. The extremity is examined by x-ray on the following days after the bacteria are injected: 32, 40, 48, 55 and 68 days. At this time the epiphysis is secondarily involved and the infection has extended down into the shaft of the tibia.

articular surface of the tibia in a rabbit that died two months after receiving an intravenous injection of staphylococci. The greater part of the articular cartilage in this animal is eroded and the epiphysis is destroyed in focal areas by a necrotizing process which extends down to the epiphyseal line.

The rabbits that survived the staphylococcic infection for five to six months showed the infected joints to be slightly larger than the normals. There usually was a little purulent exudate in the joints even at that time. The synovial membranes were smooth and glistening. The articular cartilages in rabbits with a purulent arthritis showed a moth-eaten surface similar to that observed in infected joints after the first month of the infection.

DISCUSSION

The observations made in this study on the pathogenesis of purulent arthritis in the adult rabbit show that staphylococci localize in the joints within twenty-four to forty-eight hours after the intravenous injection of a broth culture of the organism. The bacteria isolated from the articular lesions are the same strain as those injected. The presence of an acute inflammatory reaction and the demonstration of bacteria both by cultural methods and in the tissues indicate that staphylococci pass through the blood stream directly to the synovial membranes. The inflammatory reaction progresses until the joint cavity is filled with a purulent material. The articular cartilage is eroded after being in the presence of this exudate for approximately two to four weeks. Bacteria apparently may invade the epiphysis secondarily through the perforations in the cartilage and may extend down into the epiphysis.

The localization of staphylococci in the joints apparently cannot be considered the results of any special affinity of this strain of staphylococci for synovial membranes. These organisms produced abscesses in muscles and viscera in the same rabbits that develop purulent arthritis.

There appears to be insufficient evidence at the present time to consider any strains of staphylococci specific for bone. It is suggested that lesions may develop where even staphylococci may localize. The development of a lesion, of course, is influenced by the number of bacteria, their virulence and the local and systemic immunity.

In a previous study it was shown that staphylococcic antitoxin either completely inhibits or delays the time at which death occurs in rabbits receiving intravenously broth cultures of staphylococci.[8] It is suggested that when death does occur before forty-eight hours it may be the result of the action of the staphylococcic toxin which had been produced in vivo. Staphylococcic antibodies in both the actively and passively immunized animal apparently neutralize staphylococcic toxin.

It is impossible at this time to compare the frequency of purulent arthritis in the three groups of normal and active and passively immunized rabbits. Apparently the immunized animals survive the lethal effects of this culture of staphylococcus through their ability to neutralize the toxin liberated by this bacterium in vivo. The organisms reach the joints through the blood and also may produce an inflammatory reaction in the adjacent soft tissues. The frequency and the number of joints involved apparently are influenced by the number of bacteria circulating in the blood.

The pathogenesis of the purulent arthritis which follows the intravenous inoculation of staphylococci in this group of adult rabbits is different to that which has been described in young rabbits. In the former the bacteria pass directly through the blood stream to the synovial membranes. In the latter, they localize in the metaphysis and may subsequently pass into the joint cavity.

The arthritis which develops following the intravenous inoculation of staphylococci in the adult rabbit is always similar to the lesion which follows the intra-articular injection of the same organism into the knee joints of adult rabbits.

SUMMARY

The pathogenesis of the purulent arthritis following the intravenous injection of a broth culture of Staphylococcus aureus into the adult rabbit is discussed. It is suggested that the bacteria pass directly through the blood stream to the synovial membranes. The articular cartilage is eroded subsequently to the formation of the purulent exudate. Staphylococci may invade the epiphysis secondarily through the erosions in the articular cartilage.

The number of joints involved and the frequency of arthritis in the normal and immune rabbit apparently is influenced by the number of bacteria circulating in the blood stream.

The arthritis which develops following the intravenous inoculation of staphylococci is similar to the lesion that occurs after the intra-articular injection of the same organism.

There is apparently no association between the strain of staphylococci used in this study and the development of lesions in bone. It is suggested that there is insufficient evidence at this time to warrent a classification of "osteomyelitic strains of staphylococci."

REFERENCES

1. Hobo, T. *Acta scholae med. univ. imp. in Kioto*, 4: 1, 1921–1922.
2. Robertson, D. E. *J. Bone & Joint. Surg.*, 9: 8, 1927.
3. Thompson, R. H. S. and Dubos, R. J. *J. Exper. Med.*, 68: 191, 1938.
4. Kisler, Gene R. *Proc. Soc. Exper. Biol. & Med.*, 34: 829, 1936.
5. Lexer, E. General Surgery. New York, 1910. D. Appleton & Co.
6. Rigdon, R. H., Joyner, A. L. and Richetts, E. T. *Am. J. Path.*, 10: 425, 1934.
7. Rigdon, R. H. and Freeman, P. R. *J. Lab. & Clin. Med.*, 25: 1125, 1940.
8. Rigdon, R. H. *J. Lab. & Clin. Med.*, 23: 159, 1937.
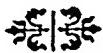
POSTOPERATIVE INFECTION*

ITS CONTROL BY SURGICAL TECHNIC

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MEDICINE and surgery have come a long way since Semmelweis in 1847 to 1849 showed that infection can be carried on presumably clean hands. His principles, modified by newer knowledge, still remain the basis of modern aseptic surgery. But even with our advanced state of information, the incidence of postoperative infection is far too great.

It is generally estimated that from 3 to 5 per cent of all cases of surgical intervention with clean wounds are followed by postoperative infection. But not so many years ago, Meleney[1] observed that, if the operators rather than interns attended to removal of the stitches from the wounds, they would lose much of their false sense of security. He estimated that not 5 per cent but about 15 per cent of clean wounds become infected.

This figure is undoubtedly much higher than the present rate of postoperative infection, for we have improved our surgical technic and have learned more about the causes of such infections during the last few years. However, it is my opinion that the occurrence of infection in a clean wound can be reduced even further. It has always seemed to me that, as in all fields of modern medicine, the answer lies in prophylaxis rather than in later attempts at cure.

At the De Courcy Clinic we have lessened postoperative infection by adherence to four simple principles, namely, (1) the avoidance of contact with pus, (2) gentle handling of tissues, (3) care in the use and tying of sutures and ligatures and (4) reduction of operating time to a minimum consistent with good operative technic.

Instruments should be substituted for the hands whenever possible when handling pus or an infected wound. Unlike the hands, instruments, ligatures, gauze and all other similar objects coming in contact with the field of operation can be absolutely sterilized. Bacteria-contaminated materials of this type are almost unforgivable with the available methods of sterilization and disinfection. Proper care can eliminate instruments completely as a source of postoperative infection.

Surgeons have come to learn that gloves are not always dependable sources of protection, either for the operator or for the patient. In England, two years ago, when tracing down the source of Staphylococcus aureus postoperative infections, Devenish and Miles[2] found that punctured surgical gloves are a very common occurrence. Leaks were present in 24 per cent of 6,585 patched and unpatched rubber gloves. Even during a period when special care was taken to avoid punctures, holes appeared in over 14 per cent of the gloves. In a few instances, the punctures were discovered as soon as they were made; but in most cases the holes were found only at the end of the operation when tests were performed. By this time there had been ample opportunity for leakage.

The search narrowed down to two surgeons who performed most of the operations in this hospital. Though both were carriers of a virulent strain of Staphylococcus aureus, only one carried such organisms on his hands. His were the cases in which postoperative infections appeared. Tests showed that these bacteria passed not only through leaks in his gloves but

also via the sweat through the sleeves of his coarse linen operating gown. The institution of suitable precautionary measures was followed by disappearance of the sepsis.

Very recently Hirshfeld[3] checked the gloves in the operating rooms in the hospital with which he is associated. He found a puncture incidence of 18 per cent in 429 gloves. In most cases, the members of the operating team did not realize that their gloves had been torn. He cultured gloves which had been worn for various periods of time and found that the number of organisms recovered varied from 1000 to over 1,000,000, depending upon the individual, the amount of perspiration in the glove and the length of time it had been worn.

This result clearly demonstrated that an enormous number of organisms may escape from a torn glove in a drop of sweat. The hazards presented through torn gloves is even more evident when it is remembered that the gloves worn by most surgeons are extremely thin and delicate.

In addition to these hazards, recent work (McCormick and Ramsey[4]) indicates that lycopodium powder or talc, used on the hands and gloves preceding operative procedures, forms another potential danger factor. When introduced into the tissues from the gloves of the surgeon or of his assistants, either or both of these powdered materials may produce an inflammatory reaction of the granulomatous type.

We cannot, however, depend too much upon the preoperative scrub-up procedure. Much has been written about disinfection of the hands before operating, yet no fully satisfactory method has been developed. All surgeons are conscientiously trying to improve their technic, but many believe that the ten-minute scrub is not only not the answer but in many instances is actually harmful. Anyone who has had to scrub-up several times each day will appreciate what I mean.

The ultimate aim, of course, is to make the hands and forearms practically free from pathogenic organisms before operating, because, as I have indicated, gloves are not always dependable. However, practical considerations show that such sterilization is impossible. By scrubbing we can hope only to remove the gross dirt from the hands and arms. The sweat glands and the skin follicles cannot be reached. Disinfectants cannot kill germs without some injury to the normal protective surfaces of the hands.

Yet the essential purpose of thorough preoperative washing cannot be minimized. It has been found that the organisms which remain on the skin after scrubbing multiply rapidly under rubber gloves (Hirshfeld[3]).

In my opinion, vigilant prophylaxis is the answer and avoidance of contact with pus is a most important part of such prophylaxis. If the surgeons' hands and the hands of their assistants never come in contact with pus, the chances are that the glands and follicles of the skin will be free of pathogenic organisms. In fact, a surgeon once remarked to me that he would rather have a carpenter come down off a roof and, after washing the gross dirt off his hands, put his hand in his abdomen than he would a surgeon who had recently handled a pus case with his own hands and then scrubbed them for ten minutes.

This may seem far fetched, but I believe that it is the answer to clean surgery. Indeed, it has been shown that, if the skin is constantly exposed to certain organisms, these bacteria eventually become part of the skin's resident flora (Price[5]).

I have always made it a policy never to dress an infected wound without wearing gloves and then never to touch the pus with the gloved hand unless it is absolutely necessary, as when operating for a ruptured appendix or the like. I have always used instruments to handle the dressings and I have taught this practice religiously to students and nurses with whom I have come in contact. This procedure and the reasons for it should be taught to interns as

soon as they enter their hospital period. The technic is easily acquired and after a time one begins to dread pus as he would the plague.

Gentle handling of tissues is another requisite if postoperative infection is to be reduced, but here, too, instruments should be used rather than the hands. Avoidance of direct handling of the tissue as far as is possible and a delicate atraumatic technic are the marks of an able surgeon. It is obvious that overmanipulation of the tissues readily results in trauma and lowered resistance to local infection.

Let instruments, which can so readily be disinfected, serve in place of the fingers. The most important instrument for handling tissue, in my opinion, is the mouse-toothed forceps. In doing many operations, in most appendectomies and herniotomies, my fingers and those of my assistants never touch the tissues.

Use of as fine catgut as is consistent with strength is also an important part of surgical prophylaxis against postoperative infection. Suturing materials of larger diameter may offer certain manipulative advantages without contributing additional strength to the wound and should be avoided. Such sutures produce an excessive quantity of foreign body in and about tissue that should be given every opportunity to heal quickly and cleanly. Thicker sutures not only predispose to delayed wound healing but also to infection.

Finer catgut sutures also permit more accurate approximation of the wound edges, with less tendency to trauma, with better hemostasis and with more freedom from possible reaction. Knots are also more secure with finer suturing materials. However, the knots should not be tied too tightly. Knots should be tied artistically rather than as by one doing a trade, but too much time should not be incorporated in a tie.

If the principles previously outlined are scrupulously adhered to, it will not matter in our final results whether we use catgut or silk. Though not all surgeons will agree with my choice, I still prefer catgut because it makes for a quick technic and because, normally, in spite of all precautions, a slight infection will occasionally result. If an infection does result after using silk, sinuses may develop in the wounds and they will not heal until the silk is removed or expelled. Such sinuses frequently persist for months. I have frequently seen such cases in which operations were performed by men who preferred to use silk. Nylon sutures offer interesting potentialities, but their introduction is too recent for sufficient accurate clinical data to have been accumulated.

In my experience, another cause of postoperative infection has been long operations. By long operations. I mean those lasting over one hour. Operations lasting three to five hours are not unusual today. The average operation, as for thyroidectomy, appendectomy, hysterectomy, gastroenterostomy and the like, should never exceed one hour. Gastrectomy sometimes requires one hour and a half, but I fail to see what surgeons can do for six hours in any of these cases. I am not prepared to speak for brain operations but these surgeons seem to be the greatest offenders.

If our surgical predecessors of preanesthetic days taught us anything, they taught us the value and importance of speed and dexterity in surgical procedures. Perhaps it might be a good thing for surgery in general if more of the modern operators claimed their share of this heritage. Unfortunately, the drain of unusually long-drawn operations upon the strength of the patient is too frequently reflected in postoperative shock and slow recovery. Nor must we forget that the longer the patient is upon the operating table, the greater the chances of infection. It has been shown that the number of bacteria that can be recovered from the skin increases as the length of an operation increases (Ives and Hirshfeld[6]). Moreover,

the strain upon the nerves of the surgeon during an excessively long operation is incalculable. Such strain necessarily impairs his technic.

I should like to comment briefly on certain recent, though not fully evaluated, developments that may have some influence in preventing postoperative infection. I refer to the revival of Lister's idea that the air of operating rooms should be rendered as sterile as possible. Lister employed phenol sprays, but today germicidal aerosols and irradiation by ultraviolet light are employed for atmospheric sterilization. Aerosols, which are antiseptic mists against airborne organisms, are still very much in the experimental stage and evidently not widely used in operating rooms (Robertson et al.[7]).

Considerable attention has been given to the employment of bactericidal radiant energy and enthusiastic reports of its efficacy in eliminating air-borne contamination of the operative wound and sterile supplies have appeared in the literature (Hart[8]). However, much more recent studies (Rice and Weed[9]) indicate that, while the bacterial content of the air in the operating room may occasionally be a source of infection for a clean surgical wound, the importance of this source of infection has been greatly overemphasized.

It is my opinion, and I am sure that others share my views, that avoidance of speech and the use of suitable, well fitting face masks are of more importance in the prevention of infection from air-borne bacteria. Indeed it has been said that the hazards presented by a torn glove are greater than those offered by the air (Hirshfeld[3]).

SUMMARY

Prophylaxis is more important than cure in preoperative preparation of the hands. Preparation should start during the surgeon's intern days rather than ten minutes before an operation.

Instruments should be used rather than fingers. The surgeon using his hands the most has the most infections.

Catgut should be used sparingly and should be of as small caliber as is consistent with the strength required.

Operations should be done in as short a time as is consistent with careful and painstaking surgery. Thoughtful surgeons anticipate their next moves. No ordinary operation need exceed one hour.

REFERENCES

1. Meleney, F. L. Infection in clean operative wounds; 9 year study, Surg., Gynec. & Obst., 60: 264, 1935.
2. Devenish. E. A. and Miles, A. A. Control of staphylococcus aureus in operating-threatre. Lancet, 1: 1088, 1939.
3. Hirshfeld, J. W. Bacterial contamination of wounds from the air, from the skin of the operator and from the skin of the patient. Surg., Gynec. & Obst., 73: 72, 1941.
4. McCormick, E. J. and Ramsey, T. L. Postoperative peritoneal granulomatous inflammation caused by magnesium silicate. J. A. M. A., 116: 817, 1941.
5. Price, P. B. Bacteriology of normal skin; new quantitative test applied to study of bacterial flora and disinfectant action of mechanical cleansing. J. Infect. Dis., 63: 301, 1938.
6. Ives. H. R., Jr. and Hirshfeld, J. W. Bacterial flora of clean surgical wounds. Ann. Surg., 107: 607, 1938.
7. Robertson, O. H., Bigg, E., Miller, B. F. and Baker, Z. Sterilization of air by certain glycols employed as aerosols. Science, 93: 213, 1941.
8. Hart, D. Sterilization of air in operating room by bactericidal radiant energy; results in over eight hundred operations. Arch. Surg., 37: 956, 1938.
9. Rice, T. B. and Weed, L. A. The bacterial content of air in the operating rooms, Surg., Gynec. & Obst., 73: 181, 1941.
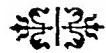
PERSISTENT EXTERNAL INTESTINAL FISTULA

REVIEW OF THE LITERATURE WITH REPORT OF AN UNUSUAL CASE FOLLOWING APPENDECTOMY

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THE purpose of this paper is to report an unusual case of persistent intestinal fistula following appendectomy and to discuss the cause, prevention and present status of management of this distressing condition. Diseases of and operations on the appendix together constitute the foremost causes of external intestinal fistulas according to Dean Lewis and associates.[1] First place among the unfortunate sequelae of appendectomy is given to intestinal fistula by Royster[2] in his work on appendectomy. Howard A. Kelly[3] quotes five surgeons as having respectively 3.5 per cent, 4 per cent, 18 per cent and 6.6 per cent of intestinal fistulas following appendectomy. Pfiefer and O'Connell[4] reported 1.4 per cent of intestinal fistulas based on over 3,000 cases of appendicitis. From an etiologic standpoint intestinal fistulas have been placed in two general groups. Those which are intentionally established by such operations as colostomy, enterostomy, appendicostomy and cecostomy; and those which are produced by some pathologic process or by trauma, for example, actinomycosis, tuberculosis, malignancy, gun-shot wounds, regional enteritis and penetrating wounds or surgical accidents. The fistulas which result from inflammatory diseases are most frequently the sequelae of appendicitis, diverticulitis,

or pelvic inflammatory processes. A similar classification to the above has been suggested by Rigby[5] and Coffey.[6] This paper is concerned only with the persistent type of intestinal fistula which follows appendicitis. In a review of 109 cases of intestinal fistula collected from the records of Johns Hopkins Hospital from 1890 to 1931, Lewis and Penick[1] made the following classification: (1) subsequent to appendicitis (44.9 per cent), (2) associated with other infections (12.8 per cent), (3) attributable to malignancy (2 cases), (4) resulting from trauma and nonoperative measures (5 cases), (5) following operations (19.2 per cent). It has been estimated that approximately 4 per cent of cases of appendicitis are followed by intestinal fistula. Many such fistulas communicate with the cecum. In recent years it has been observed that a considerable number of fistulas follow removal of an inflamed appendix in cases in which terminal ileitis or typhlitis is present. A fistula may follow evacuation of an appendical abscess in cases in which it does not seem feasible to remove the remnant of appendix at the primary operation. A fecalith in the remaining portion of the appendix may be responsible for the formation of such a fistula. Baldwin[7] and Deaver[8] have advanced strong arguments against inversion of the appendical stump. Harris,[9] of San

Francisco, reports a fatality following the pricking of a small vessell in the wall of the cecum while placing the purse-string suture.

Roder,[10] of Omaha, found that of one hundred appendectomies made with the purse-string suture, 88 per cent of the needles and remaining pieces of suture gave positive growths on culture media, proving clearly that the needle had penetrated one or more times the mucous membrane of the cecum. He also called attention to the added danger when the base of the appendix is crushed, since his laboratory investigation had shown that the crushing clamp was found to be frequently contaminated by the infectious material forced to the surface by the crushing process. Furthermore, the ligature which is placed in this crushed groove is not only in an infected field but in devitalized tissue very likely to give way from internal pressure, conditions very different from those described and illustrated by Seelig.[13] Horsley[11] calls attention to the perfect incubation chamber furnished by the purse-string enclosing the depressed stump, as presenting "first, the diminution of the blood supply to the tissues; second, the presence of necrotic material; and third, the formation of a closed sac;" all perfect conditions for abscess formation Babcock[12] concerning the purse-string suture states: "Purse-string, occluding, or enfolding sutures in the caecum, after removal of an infected appendix, are unnecessary and harmful, favoring large sloughs in the head of the caecum." J. F. Baldwin[7] reported 3,215 operations for appendicitis without an intestinal fistula since he abandoned the purse-string inversion of the stump of the appendix. What particularly drew Baldwin's attention to the dangers of a purse-string was the large percentage of intestinal fistulas reported by surgeons who use that method. The chief objections to the purse-string treatment are: (1) It requires much more time; (2) it necessitates more mobilization of the cecum; (3) there is very great danger (88 per cent according to Roeder)

of the needle penetrating the bowel with resulting peritonitis; (4) distinct danger of a hematoma from pricking a vessel; (5) danger of necrosis of the encircled wall of the cecum from diminished blood supply; (6) great increase of postoperative adhesions, with resulting postoperative ileus; (7) greatly increased danger of fecal fistulas; (8) the constant menace from burying the necrotic stump in a perfect incubation chamber. The purse-string method is condemned by many surgeons of large experience, many of whom are professors of surgery in medical colleges and by many of national and international reputation so that their opinions are certainly entitled to serious consideration. The simple drop method which was used in Mt. Sinai Hospital in New York when Seelig[13] wrote his article condemning the purse-string is still in use by all of its surgeons and A. A. Berg of that hospital writes as follows: "it has been the method of choice there for the last forty years. I have used it in thousands of cases and have never known a faecal fistula to develop after its use. The procedure is surely the simplest procedure that can be employed. The method is speedy and safe." Robert T. Morris, of New York, published an article detailing his technic in appendectomy which was the same as Seelig's. He stated that he had had no fistulas since he had given up the purse-string suture and had adopted the simple method of Seelig. It has been shown recently by Harry M. Weber and C. Allen Good, Jr.[14] that an invaginated appendiceal stump persists after many years with the inverted stump projecting as a bulbous mass into the lumen of the cecum, resulting in persistent pain and tenderness with the production of polypoid lesions. Charles W. Mayo[15] condemns inversion of the carbolized stump of the appendix and advocates the simple drop stump method. Frank Lahey[16] abandoned the purse-string inversion of the stump about fifteen years ago for the simpler, noninversion method of Seelig. The writer who has employed the simple drop method

in 1,125 appendectomies has had one case of cecal fistula and this followed the removal of a ruptured gangrenous appendix with neglected abscess in which the gangrene had extended to the cecum. This fistula closed spontaneously in four months.

The drain employed at an abdominal operation may be responsible for a postoperative fistula. However, practically every writer on the subject has concluded that the use of drainage material is definitely indicated under such conditions as that of appendical abscess. Hard rubber drains may produce pressure necrosis of a portion of intestinal wall and give rise to a fistula. A fistula is likely to follow any extensive operation in the presence of infection or potential infection. Retained gauze sponges, unabsorbed ligatures, parts of surgical instruments or fecaliths may be the cause of failure of a surgical wound to heal. Incomplete removal of a diseased portion of intestine may be followed by a postoperative fistula or such condition may ensue from disturbance of the blood supply, to bowel wall or other operative trauma. All are agreed, however, that the commonest cause of an intestinal fistula is appendicitis and fistulas have been reported at all levels of the gastrointestinal tract from the duodenum down to the rectum following appendectomy.[8] An intestinal fistula following appendicitis is becoming less common. In fact, it has become very rare with the advent of earlier operation and a more simplified technic. This is extremely fortunate because the cure of these fistulas, especially the persistent variety, presents many serious and difficult problems.

SYMPTOMS

The symptomatology of course is determined by the segment of intestine involved. The closer the opening to the duodenum the more serious the fistula because of the digestion of the abdominal wall and the loss of fluids. Severe toxemia is produced in the high type of intestinal fistula because of the loss of electrolytes, biliary and pancreatic secretions. Walters and

Bollman[17] have shown that the same effects follow obstruction high in the intestinal tract, namely, there is an increase in the blood urea and in the carbon dioxide combining power of the plasma, and a decrease in the chlorides of the blood. If the fistula arises high in the intestinal tract as in the duodenum or jejunum, there is usually marked excoriation of the skin as a result of the action of the digestive enzymes. Inasmuch as four quarts of fluid may be lost daily through a high intestinal fistula, dehydration can be extreme. The loss of gastric secretions alone results in alkalosis, while the loss of pancreatic secretions alone will tend to result in acidosis. In many cases, however, the presence of a fistula diverts quantities of both to the surface.

DIAGNOSIS

The diagnosis of external intestinal fistula is usually obvious, although Baldwin[7] expressed the belief that the odor of infection caused by colon bacilli in the wound, and that caused by the fecal material discharged from a fistula may easily be confused by those not familiar with either condition. If the opening in the intestine is very small and the amount of drainage is slight, a history of the passage of gas through this opening helps to establish the diagnosis, or the taking by mouth of dye such as carmine red or methylene blue may reveal whether or not a fistula is present. Purulent material mixed with the fecal discharge indicates infection or abscess about the sinus.

PROGNOSIS

The prognosis depends usually on the site of origin of the fistula, that is, the segment of intestine involved. The prognosis usually improving as one approaches closer to the anus. Colp[18] reported a mortality rate of 51 per cent in cases of duodenal fistula with death occurring as early as three days subsequent to formation of the tract. Fistulas of the upper part of the intestinal tract do not heal spontaneously

as often as those which arise from the more distal segments of bowel. For those requiring operation the prognosis should be guarded. MacLaren[19] found that 19 per cent of seventy-seven patients died following closure of a sinus that appeared after appendectomy. Deaver[8] reported a mortality rate of 49 per cent in 222 such cases in which operation was required. Rankin and Gorder[20] reported twenty-seven deaths in 264 cases in which 379 operations were performed, a mortality rate of 10.2 per cent. The above figures will indicate that the mortality rates reported are extremely variable. The explanation for this is obvious for the factors involved are numerous. In general, it may be said that the general condition of the patient, the type and extent of the fistula, and the skill of the surgeon are the three chief determining factors in mortality rate.

TREATMENT

Prevention of course is the keynote and deserves special emphasis, but sometimes in spite of one's best efforts an intestinal fistula will result. When the fistula appears every effort should be made to help the closure of this fistula spontaneously, that is by medical means. Fistulas which are distinctly more proximal to the anus, that is the so-called "low" fistula, heal spontaneously in from 39 to 88 per cent of the cases.[21] Conservative measures should be tried for from six to twelve months whenever possible before radical methods are employed. The length of time that operation can be deferred will be determined by the level of the fistula, the amount of inconvenience the patient suffers and by his general condition. Conservatism can not be emphasized too strongly. The number of devices and methods of conservative management which have been advocated for the closure of intestinal fistulas are very numerous and it is evident from this that no one method is satisfactory in all cases. Potter[23] employed a Bradford frame on which the patient lay prone. In this method an opening through the frame

permits drainage to take place into a bed pan. Erdman[24] treated an intestinal fistula by means of an apparatus for continuous suction which he suspended from a semicircular rod designed by Pool. Ochsner[25] administers egg white orally and this was successful in lessening excoriation. Cameron[26] reported closure of a duodenal fistula in eleven days following continuous use of suction through a catheter placed in the opening of the fistula. Judd[27] and Dixon[28] have also treated duodenal fistulas by this method. Rees[29] obtained a satisfactory result by employment of dressings of commercial dried whole milk. Potter[23] advocated a solution of beef broth and 10th normal hydrochloric acid, with subsequent use of commercial peptone solution (Witte's) to absorb the enzymes. Warshaw and Hoffman[30] introduced hydrochloric acid directly in the sinus and kept the adjacent skin bathed in peptone solution. The injection of bismuth paste still has its proponents. Plugging of the external opening of the sinus tract has been advocated. The plugs have been made of various materials ranging from ordinary gauze packing to tampons of iodoform gauze impregnated with 10 per cent camphorated oil to prevent saturation with secretion and to preclude the concomitant maceration. Chewing gum has been employed as a plug. Of course all such plugs are kept firmly in place by a sponge held *in situ* by adhesive tape or by a tight belt or binder. Plugging of course is contraindicated in the presence of inflammation. Any plan that will prevent dehydration and irritation of the structures adjacent to the fistula is obviously of great help in preparing the patient for operation if this is unavoidable. According to Ochsner,[25] Reyband, in 1827, advocated the insertion of wood or ivory plates into the fistulous opening and Kleybolte, in 1842, described two leather discs connected by a thread which were used for this purpose. Recently Marshall[31] of the Lahey Clinic has reported the use of a button device which appears to be an elaboration of the plan of Reyband. A large flexible

rubber T-tube has been devised especially for use in the treatment of a fistula of the spur type. A thorough attempt at conservative closure is advocated by most authorities before radical methods are employed.

Excoriation of the skin which accompanies intestinal fistula is a factor of greatest concern to the patient, and is perhaps the most urgent condition at the beginning of treatment. That this excoriation is extremely difficult to control is evidenced by the numerous devices and medications advocated for its relief. Constant suction seemingly gives the most nearly universal relief as it removes the offending fluid before it attacks the skin margin. If dressings are applied, the offending fluid is retained in proximity to the skin and maceration is encouraged. A lighted hood helps keep the skin dry and may help to prevent the action of enzymes on the skin and also makes dressings unnecessary. Frequent tub baths have been advocated to relieve the distress of excoriation. Co Tui[32] experimented with kaolin in the care of high intestinal fistulas. Occasionally, an ointment made with kaolin and mineral oil or kaolin and zinc oxide is effective in protecting the skin. The introduction of iodized oil into the fistulous tract has been recommended by Alton Ochsner because of its healing properties and bactericidal activity. Aluminum paint mixed with cold cream until it has a buttery consistency has also been recommended and has been used by the writer. This makes an impervious covering which cannot be washed off. Dixon and Deuterman[21] have used a 10 per cent solution of tannic acid sprayed over the tissues with an ordinary atomizer and claim immediate temporary relief from the distress which accompanies excoriation.

Conservative therapy may fail for numerous reasons, the chief cause being obstruction of the portion of intestine distal to the fistula. Recently we cared for a patient for whom expectant and medical treatment certainly had been given a fair trial over a period of many months and who in addition went through two unsuccessful attempts at surgical closure of the fistula.

CASE REPORT

CASE I. A man, aged forty-one, was referred to me on August 2, 1938 for treatment of a persistent intestinal fistula in the right upper quadrant of the abdomen which had been present for one year. Exploration of abdomen and appendectomy with drainage had been performed elsewhere in May, 1937, for abdominal pain, indigestion, belching of gas and constipation, symptoms which the patient had had for about two or three years. An abscessed appendix was found, removed and drained. He was in the hospital eighteen days and was discharged with a slightly draining wound which healed completely after three weeks at home. He returned to work in July, 1937, but had to cease work after three weeks because of continuous abdominal pain. He re-entered the hospital in August, 1937, when the diagnosis of pelvic abscess was made and operation advised. Following this operation he developed an intestinal fistula which was noted immediately postoperatively. An attempt was made to close the intestinal fistula four weeks later without success. A second attempt was made to close the fistula four weeks later and this, too, was unsuccessful, the fistula appearing again three days postoperatively. He was in the hospital three months at this second admission during which time he had had three operations. He left the hospital with a draining fistula through the midportion of the abdominal incision. The patient was losing weight and strength, was unable to work and the fistula was producing so much digestion and excoriation of the skin that the patient returned to the hospital again in May, 1938, and a rubber T-tube was put in which he wore for two months without much relief of symptoms. He was finally referred to Doctor Anthony Bassler, in New York, with regard to the advisability of making an "effort to block the external opening with a rubber cast large enough to close it" since the rubber T-tube was ineffective. Doctor Bassler considered this procedure inadvisable and recommended removal of the T-tube and surgical closure of the fistula. On July 8, two months after its insertion, the T-tube was removed under general narcosis and a button device was inserted which stayed in about three weeks and then worked out.

Another improved model of button was inserted and that worked out after several days. The fistulous opening in the abdominal wall was growing progressively larger. Undigested food appeared through this enlarged opening twenty minutes to one-half hour after ingestion. The patient was suffering attacks of upper abdominal pain which was followed by increased drainage from the fistula. Constipation had always been a marked feature, the patient going five weeks without a bowel movement on some occasions. All the above described operations and procedures had been performed before this patient came under our care.

Physical examination revealed an emaciated, debilitated, adult male of forty-one, six feet one inch tall who appeared chronically ill, nervous and apprehensive. He walked somewhat bent forward and to the right.

The chest was negative to examination. The rest of the physical check-up revealed nothing except for the presence of a large draining abdominal fistula in the midportion of a scar ten inches in length. The scar commenced just below the ensiform in the midline and ran downward slightly oblique to the right of the umbilicus and extended down for another five inches below the umbilicus to the right lower quadrant. The fistulous opening measured $5\frac{1}{2}$ cm. in diameter and was at about the midportion of the scar about two inches lateral to the umbilicus. The opening was surrounded by a region of granulation tissue and marked excoriation of the skin was present.

Roentgenologic examination after the injection of bismuth paste revealed a large sinus tract communicating with the small intestine. Barium by mouth and serial plates yielded no additional information. Examination after a barium enema had been given revealed that the sinus tract did not communicate with the colon.

The patient was admitted to St. Francis Hospital, in Poughkeepsie, New York, on August 2, 1938. He was given a residue free diet; the gastrointestinal tract was cleansed by means of saline irrigations and mild saline cartharsis. Laboratory studies were done: Blood count: hemoglobin 70 per cent; red blood cells 4,800,000; leukocytes 6,750; polymorphonuclears 55 per cent, lymphocytes 39 per cent, large mononuclears and transitional 1 per cent, eosinophiles 5 per cent. Urine analysis: Amber, cloudy, acid, specific gravity 1.030, albumin—

trace, sugar—negative, crystals calcium oxalate, few epithelials.

On August 6, (four days after admission), under general narcosis, the large fistulous opening was packed with iodoform gauze and circumscribed, the surrounding granulation tissue and the midportion of the old operative scar were excised removing an elliptical piece of the abdominal wall with the fistulous opening as its center. The peritoneal cavity was opened. After freeing this segment it was lifted out, bringing with it, attached to its undersurface two coils of small intestine with fistulous openings into either side of the large external fistula. The large external fistula consisted of a dilated proximal and distal loop of small intestine. The two loops of small intestine communicating with the large external stoma were dissected off. The openings in the communicating loops of small intestine (internal fistulas) were closed with two layers of intestinal dulox using a Connell suture for the first layer and a Lembert suture for the second layer. The closure was reinforced with fine interrupted linen. The openings in the small intestine were sutured transversely to the long axis of the bowel in order not to narrow the lumen. The large external fistula, which consisted of a dilated proximal and distal loop of small intestine, was separated, the ends resected so as to create two oblique openings, the longer ends on the mesenteric border. An end-to-end anastomosis was done after the method of Lockhart-Mummery.[22] This anastomosis was also reinforced with interrupted linen sutures. Exploration of the abdomen and the right lower quadrant revealed no remaining appendix. Dense peritoneal adhesions were liberated. A layer closure of the abdominal wall was done with interrupted sutures of chromic No. 2 for peritoneum and fascia, dermal and silk-worm gut for the skin with penrose tube drainage to the fascia. Convalescence was uneventful, temperature and pulse returning to normal and remaining there after the fifth postoperative day. The wound healed by primary union except at the drain site which healed by granulation. The superficial sutures were removed on the eighth postoperative day. The deep sutures were removed on the twelfth postoperative day. The patient was permitted out of bed on the twelfth postoperative day and was discharged on the fifteenth postoperative day (August 21, 1938) with the incision closed and well healed.

Pathological studies of the fistulous tract revealed only chronic inflamation.

The patient has remained well to date. Follow-up examination on May 17, 1941, (two years postoperatively) finds this man the picture of robust health. He is symptom free. The abdominal incision is well healed without a hernia. He has lost no time from work and follows a regular diet. His bowels move every two days but he is not uncomfortable and takes no laxatives. He has regained his normal weight of 178 pounds which is a gain of sixty-three pounds, having weighed 115 pounds during his illness. He was recently passed by two separate companies for considerable sums of life insurance. This case teaches that great lesson of courage.

PREOPERATIVE TREATMENT

Before attempting to close an intestinal fistula the intestinal contents should be evacuated thoroughly by means of irrigation. The patient should be given a non-residue diet for several days prior to surgical intervention and a saline laxative to promote complete emptying of the intestines. Fluids, fruit juices and candy are forced so as to build up a carbohydrate reserve to protect the liver, and to change the bacterial flora of the bowel. The site and character of the fistula must be established and the presence or absence of obstruction in the distal loop must be determined by x-ray. This is not always easy and sometimes impossible as was demonstrated in the case reported above. It is essential to detect the chemical or fluid imbalance that so frequently occurs. Loss of chlorides and water must be replaced in every possible way. The patient should be adequately prepared before operation.

SURGICAL TREATMENT

Since the persistent variety of intestinal fistula is obviously due either to disease in the wall of the affected segment of bowel or to distal obstruction, any procedure for relief must provide for the relief of the obstructive factor and for the removal of all diseased tissue. To treat such a fistula merely as an abnormal opening to be closed by some plastic procedure is from this point of view inviting almost positive failure. Surgical intervention should not be undertaken too lightly and only in the cases that do not close spontaneously since operation often requires painstaking disections and calls for the highest degree of surgical judgment and skill. One of the most difficult problems arising in the surgical management of an intestinal fistula has to do with the prevention of peritonitis because the surrounding tissues cannot be satisfactorily sterilized. In the persistent type of small intestinal fistula the abdominal cavity usually has to be opened in order to obtain good exposure. Lockhart-Mummery[22] called attention to the necessity for intraperitoneal exposure to insure maintenance of the blood supply. Simple closure of the fistula consists of inversion of the mucosal edges with two or three layers of chromic catgut and suture of the skin. This procedure is not sufficiently thorough to affect a cure in the persistent case and is not advocated without qualifications by those who have had extensive experience in intestinal surgery.

A more satisfactory procedure is closure by inversion of the mucous membrane and anatomic closure of fascial, muscular and subcutaneous layers. Attention has been called frequently to the importance of maintaining an adequate blood supply in these cases and Lockhart-Mummery[22] and Dixon[28] say that the bowel should be cut at an acute angle with the mesenteric border so that more is taken from the antimesenteric border than from the mesenteric side even if it is necessary to sacrifice normal intestine. This insures a better blood supply. An ample blood supply is imperative for a satisfactory permanent closure. It is also essential to excise the portion of bowel wall which is thickened, indurated and irregular in order to obtain a satisfactory closure; and one must close an opening in the bowel so as to prevent narrowing of the intestine which might result in intestinal obstruction. If it appears that exci-

sion of the bowel wall is so extensive that the opening cannot be safely closed, a resection of the segment must be carried out and the continuity of the bowel must be restored by an end to end or lateral anastomosis. The majority of these fistulous tracts will require considerable operative ingenuity to close and no single method can be employed for all of them. The operative approach must be planned for each individual case and the details of the procedure can be determined only at the time of operation and as the operation progresses. While it is important to visualize beforehand the type of pathology that one may expect to encounter from a detailed analysis of the history, physical examination and x-ray study, yet such studies often yield little positive information preoperatively, as is demonstrated in the case reported above.

If considerable manipulation of the viscera has been necessary, an enteric stoma of the Witzel type established proximal to the anastomosis is often a life saving measure. Deaver[8] used one or more enteric stomas according to indications. C. P. Schlicke and C. F. Dixon,[33] of the Mayo Clinic, carry out an enterostomy routinely as a precaution following intestinal resections and the closure of fistulas. Unless there is considerable infection and formation of abscess about the sinus, closure without drainage of the peritoneal cavity is the rule by Claude Dixon.[28] Lockhart-Mummery[22] places a soft rubber drain down to the anastomosis and leaves the drain tube *in situ* for thirty-six hours. The multiple retention sutures of the abdominal wall can be removed on or about the fourteenth postoperative day.

POSTOPERATIVE CARE

Concerning the postoperative care of these patients constant attention to many details is essential. Fluids are restricted by mouth postoperatively and only small amounts of nonresidue liquid are given as tolerated. The fluids are gradually increased by mouth depending on the

progress of the case until the fourth postoperative day when a full nonresidue liquid may be permitted, gradually increasing the quantity until the tenth postoperative day when a smooth diet can be provided. The patient should receive about 2,000 cc. of fluid daily which may be given either as a saline hypodermoclysis or 5 per cent glucose in normal saline by the slow intravenous drip method. During the first few postoperative days, when fluids are restricted by mouth, oral hygiene is important to prevent parotitis. Lemon juice and chewing gum are helpful. Fecal inspissation and impaction must be guarded against and can be prevented by the installation of about four ounces of olive oil in the rectum daily. Irritant enemas are dangerous even after the fourth day. Deep breathing, turning in bed and exercise of the arms and legs is a wise procedure. The patient should be permitted out of bed as early as possible consistent with the magnitude of the operation.

SUMMARY AND CONCLUSIONS

1. An unusual case of persistent postappendical high intestinal type of fistula and its management is reported.

2. The etiology, diagnosis, prognosis and management of intestinal fistula is discussed.

3. Diseases of and operations on the vermiform appendix still constitute the commonest cause of intestinal fistulas.

4. Intestinal fistulas are growing less common following appendicitis since the advent of earlier diagnosis and treatment with a more simplified technic.

5. Many intestinal fistulas will close spontaneously and conservative management should be given a fair trial before surgical intervention. The mortality following surgical closure ranges from 8.9 to 50 per cent.

REFERENCES

1. Lewis Dean and Penick, R. M., Jr. Fecal fistulae. *Internat. Clin.,* 1: 111–130, 1933. W. F. Prior Co.

2. ROYSTER, H. A. Appendicitis. P. 346, 1927.

3. KELLY, HOWARD A. Vermiform Appendix. P. 674. Philadelphia, 1905. W. B. Saunders Co.

4. PFEIFER, J. L. and O'CONNELL, W. J. *Bull. Am. Col. Surg.*, p. 32, June, 1931.

5. RIGBY, H. M. A clinical lecture on intestinal fistula. *Clin. J.*, 38: 289–297, 1911.

6. COFFEY, R. C. Remote or indirect subperitoneal drainage in the extraperitoneal closure of persistent fecal fistulae. *Ann. Surg.*, 45: 827–835, 1907.

7. BALDWIN, J. F. The prevention of faecal fistula after appendectomy; simple ligation vs. precarious purse-string. *Ann. Surg.*, 95: 704–714, 1932.

8. DEAVER, J. B. External fecal fistula following appendicitis. *Ann. Surg.*, 83: 782–789, 1926.

9. HARRIS, F. L. *Calif. & West. Med.*, vol. 27, No. 1, July, 1927.

10. ROEDER, C. A. *Arch. Surg.*, 2: 18–24, 1925.

11. HORSLEY, J. SHELTON. Operative Surgery. 3d ed., pp. 777–778, 1928. W. F. Mosby Co.

12. BABCOCK, W. W. Text Book of Surgery. P. 1117, 1928.

13. SEELIG, MAJOR G. *Ann. Surg.*, pp. 710–720, November, 1904.

14. WEBER, HARRY M. and GOOD, C. ALLEN, JR. Invaginated Appendiceal Stumps Roetgenologically Simulating Polypoid Neoplasms. Collected Papers of the Mayo Clinic and the Mayo Foundation. Vol. 31, p. 831. Philadelphia, 1939. W. B. Saunders Co.

15. MAYO, CHARLES W. Appendicitis. Collected Papers of the Mayo Clinic and the Mayo Foundation. Vol. 26, p. 156. Philadelphia, 1923. W. B. Saunders Co.

16. LAHEY, FRANK. Personal communication.

17. WALTERS, WALTMAN and BOLLMAN, J. L. The toxemias of duodenal fistula; physiologic changes concerned in the production of its characteristic chemical reactions of the blood. *J. A. M. A.*, 89: 1847–1853, 1927.

18. COLP, RALPH. External duodenal fistulae. *Ann. Surg.*, 78: 725–744, 1923.

19. MacLAREN, ARCHIBALD. The closure of fecal fistulae. *Lancet*, 38: 185–189, 1918.

20. RANKIN, F. W. and GORDER, A. C. Fecal Fistula, in Rankin, F. W. Bargen, J. A., and Buie, L. A. The Colon, Rectum, and Anus. Pp. 346–358. Philadelphia, 1932. W. B. Saunders Co.

21. DIXON, C. F. and DEUTERMAN, J. L. The management of external intestinal fistulas. *J. A. M. A.*, 2095–2100, 1938.

22. LOCKHART-MUMMERY, J. P. Diseases of the Rectum and Colon. Baltimore, 1934. William Wood & Co.

23. POTTER, C. A. Treatment of duodenal and fecal fistula; further observations. *J. A. M. A.*, 92: 359–363, 1929.

24. ERDMAN, SEWARD. Laceration of duodenum; rupture of liver, duodenal fistula; jejunostomy feeding; parotiditis; recovery. *Ann. Surg.*, 73: 793–797, 1921.

25. OCHSNER, ALTON. Intestinal Fistulae, in Nelson's Loose Leaf Surgery, 5: 2951, 296E, 1928.

26. CAMERON, A. L. The treatment of duodenal fistula, with report of a case. *Surg., Gynec. & Obst.* 37: 599–606, 1923.

27. JUDD, E. S. Personal communication; Dixon and Deuterman: The management of external intestinal fistulas. *J. A. M. A.*, 111: 2095–2100, 1938.

28. DIXON, C. F. The value of sodium chloride in the treatment of duodenal intoxication. *J. A. M. A.*, 82: 1498–1502, 1924.

29. REES, C. E. Dried milk as a dressing for intestinal fistula: report of case. *Calif. & West. Med.*, 30: 419, 1929.

30. WARSHAW, DAVID and HOFFMAN, W. J. High intestinal fistula: report of case treated by modification of potter method. *J. A. M. A.*, 94: 1050–1052, 1930.

31. MARSHALL, S. F. The surgical treatment of abdominal fistulas. *New England J. Med.*, 218: 211–220, 1938.

32. CoTUI, F. W. The excoriations around external gastro-intestinal fistulae; experimental studies on their etiology and further experience with kaolin powder treatment. *Ann. Surg.*, 98: 242–248, 1938.

33. SCHLICKE, C. P. and DIXON, C. F. External fecal fistula of eighteen years' duration; report of a case. *Proc. Staff Meet., Mayo Clin.*, vol. 15, no. 26, June 26, 1940.

34. Chirurgische Operationslehre, Herausgeber; A. BIER, H. BRAUN, H. KRUMMELL: Dritte Vermehrte Auflage; Band III; Operationen am Bauch. Leipzie Verlag von Johann, 1920. Ambrosius Barth.

35. MOYNIHAM, SIR BERKELEY. Abdominal Operations. Vol. II, pp. 191–192. Philadelphia, 1926. W. B. Saunders Co.

36. McCLURE, Roy D. *Ann. Surg.*, 94: 203, 1931.

37. SOUTHAM, A. H. *Brit. M. J.*, p. 258, February 14, 1931.

38. MACHT. *Johns Hopkins Bull.*, April, 1915; also Clarke and Brown; *J. A. M. A.*, March 17, 1906.

39. BASTIANELLI. *J. A. M. A.*, p. 2148, December 23, 1922.

40. BAILEY, HAMILTON. Emergency Surgery. Vol. I, pp. 40, 44 and 274. 1930.

41. BERG, A. A. Mt. Sinai Hosp., N. Y. Personal communication.

COMPRESSION OF THE SPINAL CORD IN PAGET'S DISEASE OF THE VERTEBRAE

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PAGET'S disease of bone or osteitis deformans was first described in 1876 by Sir James Paget[1] in an address to the Royal Medical and Chirurgical Society of London. Paget was sixty-two years old at that time. The description which he gave was so clear-cut and complete and his microscopic study so exact that very little has been added by the numerous students of this disease in the next sixty-five years. Paget did not know the etiology of the condition he described but inferred that the process was inflammatory. At the present time we are not much further along.

Osteitis deformans is a rare disease but not extremely so. It has an average incidence of one case to about 11,000 hospital admissions.[2] Osteitis deformans is a general disease of the skeleton, probably due to some altered constitutional state. The chief manifestations are enlargement and subsequent deformity of the bones. The disease usually begins after the fiftieth year with neuralgic or rheumatic pains in the lower extremities. The tendency for the disease is toward a slow gradual involvement of the entire skeleton, though it may be confined to a single bone or part of a bone for many years. The bones involved in their order of frequency are: skull, tibia, femur, pelvic bones, spine, clavicle, ribs and radius.

Paget's disease is of neurologic interest because the skull and spine are so frequently implicated. Progressive loss of vision and hearing result when the optic and auditory nerves are compressed by the thickened bone in the base of the skull. The cochlea and semicircular canals which are encased in bone may be affected also.[3]

Cerebral symptoms have been reported, and these presumably are due to a reduction in cranial capacity by encroachment of the proliferating calvarium.

Fig. 1. Anteroposterior x-ray showing increased density of the bodies of the fifth and sixth dorsal vertebrae.

Although the vertebrae are often involved, compression of the spinal cord by the thickened bone is most uncommon. In 1939, Schwarz and Reback[4] in a review of the literature found only ten cases of Paget's disease of the vertebrae with spinal cord compression. They added nine cases from the extensive material at the Neurological Institute. Only three of their nine patients were operated upon.

CASE REPORT

Our patient was a fifty-three year old retired patrolman. His illness began in June, 1939,

The patient was well developed and well nourished. Except for the neurological changes there were no abnormal findings.

He had a spastic paraplegia in extension.
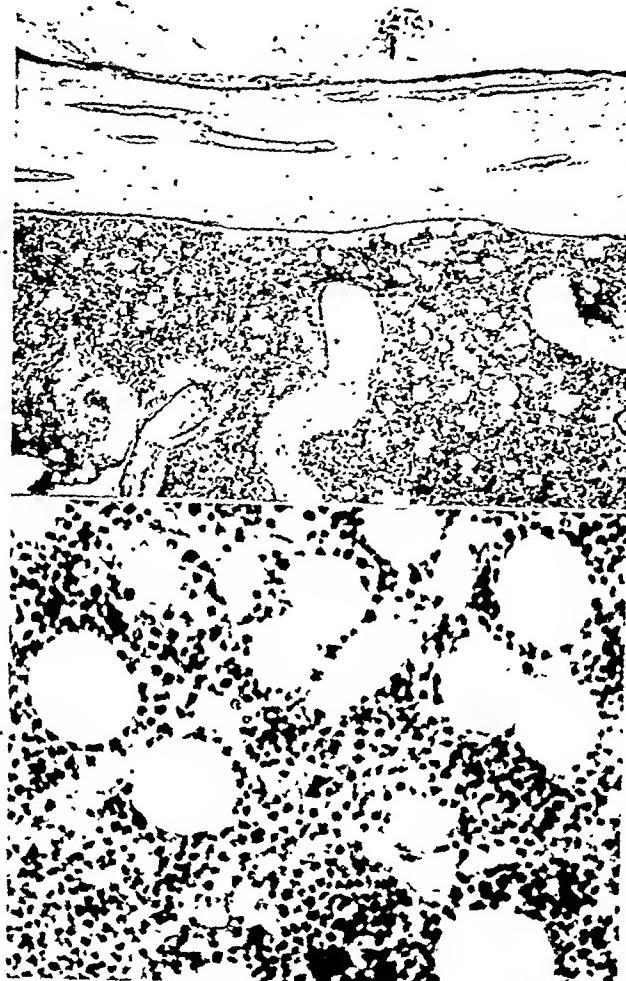
FIG. 2. Photomicrograph of section of bone removed from the lamina. × 50.

FIG. 3. Note the vascular sinuses surrounded by small round cells. × 350.

with cramp-like pains in the left knee. In August, 1939, pain in the lower extremities became more severe and he was forced to use crutches in walking. He was treated for "arthritis." By June, 1940, his lower extremities were so weak that he was bed- or chair-ridden. He continued to lose strength in the lower extremities until they were practically powerless and numb. At this time he developed incontinence of urine and feces. Examination on December 29, 1940, at the Beth David Hospital (service of Dr. L. Hauswirth) was as follows:

Voluntary movement of the lower extremities was entirely absent. The deep reflexes were markedly increased and Babinski's sign was bilaterally positive. There was a sensory level for all forms of sensation at the sixth dorsal skin segment. Beevor's sign was positive. The fourth, fifth and sixth dorsal spinous processes were tender on pressure. A spinal puncture yielded a slightly xanthochromic fluid of high protein content. There was a complete manometric block. X-ray examination of the skull, spine and extremities showed changes in the left ilium and the bodies of the fifth and sixth

dorsal vertebrae. (Fig. 1.) The body of the fifth dorsal vertebra showed marked condensation of bone while in the ilium areas of rarefaction and condensation were present side by side. These changes are so typical that they may be considered pathognomic of Paget's disease.

A laminectomy was done under general anesthesia. The spines and laminae of the fifth and sixth dorsal vertebrae were removed. The bone was markedly thickened, vascular and peculiarly brittle. The dura, arachnoid and spinal cord appeared normal. The patient had a smooth convalescence. He gradually regained the use of his lower extremities; bladder and bowel function improved; and at the time of discharge he was able to walk with assistance. The sensory changes were markedly improved.

Microscopic examination of the bone removed showed two parallel layers of compact bone in which Haversian canals are seen cut longitudinally. Between the compact bone dense trabeculae are seen surrounded by a very cellular vacuolated tissue. (Fig. 2.) This tissue is made up of small round cells with darkly staining nuclei. These cells resemble lymphocytes. Many large multinucleated cells are seen. On close inspection the large vacuoles are found to have a fine endothelial lining and they are evidently vascular sinuses. (Fig. 3.) At the last examination in June, 1941, the patient walked without a cane. The reflexes were slightly hyperactive. Babinski's sign was absent and there were no sensory changes. Bladder and bowel function were normal.

Schwarz and Reback[4] have recently discussed the pathogenesis of spinal cord compression in Paget's disease and the technical difficulties encountered in performing a laminectomy in the presence of Paget's disease of the vertebrae. The bone may be so thick that the rongeurs in common use may not open wide enough. In our case the bone was very vascular and peculiarly brittle.

This case illustrates once again that even though loss of power may be complete and of several months' duration, in the presence of spasticity and hyperactive tendon reflexes, recovery may be expected when compression of the spinal cord is relieved.

REFERENCES

1. Paget, James. On a form of chronic inflammation of bones (osteitis deformans). Tr. Med. Chir. Soc., 60: 37–64, 1877.
2. Moore, Sherwood. Observations on osteitis deformans. Am. J. Roentgenol., 10: 507–518, 1923.
3. Moore, Sherwood. Osteitis deformans and the eye, ear, nose and throat specialties. Ann. Otol., Rhinol. & Laryngol., 36: 662–665, 1927.
4. Schwarz, G. A. and Reback, S. Compression of the spinal cord in osteitis deformans (Paget's disease) of the vertebrae. Am. J. Roentgenol., 42: 345–366, 1939.
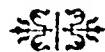
PNEUMOCOCCIC PERITONITIS

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PNEUMOCOCCIC peritonitis, which always has been relatively uncommon, has become extremely rare in the past decade due to the ever improving standards of living and the treatment of pneumonia by chemotherapy. At St. Vincent's Hospital there have been only three cases of this condition among the 70,100 admissions during the last seven years. Of these three cases one was in a child who had pneumonia, and two were in women in the fourth decade of life with the initial pathological conditions in their fallopian tubes. Therefore, of the 2,280 patients with pneumococcic pneumonia treated at St. Vincent's Hospital during these seven years, only one case of pneumococcic peritonitis resulted as a complication of the pneumonia and that case was in a child. This is amazing when one considers the number of patients with pneumonia who have a bacteriemia.

Pneumococcic peritonitis may be caused by a blood stream infection originating in the lungs or throat, but is more commonly the result of an extension of an infection of the fallopian tubes. The condition occurs most frequently in young girls under ten years of age in families of low economic strata. A positive diagnosis can be made only when the organism is found at operation or by an abdominal puncture. This latter procedure should be performed very early in the disease for fear of perforating the intestines which soon become matted together with fibrinous adhesions. At first the pus is odorless, thin, flaky and albuminous, but quickly becomes thick, creamy and fibrinous, and glues the intestinal loops together. It has a tendency to form into pelvic abscesses which often grow to large dimensions and necessitate surgical intervention with drainage, and not infrequently

the removal of the tubes and ovaries which tend to act as a constant source of infection. The blood cultures are usually only positive in very severe infections in which pneumonia, pleurisy, pericarditis or other conditions are present. If an absolute diagnosis can be made and if no abscess is present, surgery is not indicated but chemotherapy should be commenced immediately. If fluid from the intraperitoneal puncture on a smear shows Gram-positive diplococci, the diagnosis of a streptococcic or pneumococcic peritonitis is fairly certain. If facilities are available for rapid typing of the pus, early intraperitoneal injection of pneumococcic antiserum is indicated, according to Scaravelli.[9] However, although not practiced in any of the three cases here reported, it seems that if a diagnosis can be made by intraperitoneal puncture, the injection of sodium sulfapyradine in ample dosage should be carried out immediately after the diagnosis is made. This medication should be augmented by the administration of the azo-dye by mouth or vein.

The pain is usually severe in its intensity and has colicky exacerbations. The temperature rapidly rises to 104°f. or over, and the white blood count ranges from 30,000 to 40,000 cells with the polymorphonuclear count proportionately very high. There are frequently loose stools of an irritating character and cyanosis is not uncommon among children.

Pneumococcic peritonitis has been recognized as a disease entity since 1865 when Bozzola of Turin, Italy, first described a case. Since then the condition although not rare, has become increasingly uncommon. Schonenberger,[9] in a review of all the cases reported in the literature prior to 1929, found 158 cases of "localized" pneumo-

coccic peritonitis with a mortality rate of 49 per cent, and 218 cases of "diffuse" pneumococcic peritonitis with a mortality rate of 86 per cent. Bass,[3] in an excellent review of 376 cases in the literature (both localized and diffuse), reports a mortality rate of 58 per cent, and he further reports nineteen cases in twelve years on an active pediatrics service of one hundred beds. Obadalek[7] reported fifty cases in ten years in Brunn, Germany. Rolleston[8] collected only eleven cases in a series of 4,454 cases of pneumonia. Sir Barrington-Ward,[2] in 1939, reported the condition becoming increasingly rare on the pediatric service of the Hospital for Sick Children, London, during the previous ten years. Doran and Allen[4] likewise report an ever diminishing incidence of the condition on the Children's Surgical Service at Bellevue Hospital, New York.

The following are the case histories of the three patients above mentioned. Two patients recovered and one patient, who originally had a type III pelvic infection and subsequently developed a type VIII lobar pneumonia and empyema, died. Of the two patients who survived, one had a type I pneumococcic pneumonia and peritonitis, and the other had a type XXVIII pneumococcic peritonitis as a result of a pneumococcic salpingitis. Thus it appears that no one particular "type" of the organism has a predilection to spread to the peritoneum.

CASE REPORTS

CASE I. J. R., a twelve year old Porto Rican girl was treated from July 7, 1933, to October 15, 1933, for intestinal parasitic infections. She was readmitted to the hospital on October 24, nine days after being discharged, with a type I pneumococcic lobar pneumonia. She was treated with type I pneumococcic serum. On November 6, 1933, a large inflamed and indurated area appeared on her abdominal wall just above the umbilicus. This area persisted for several weeks and then became necrotic and sloughed its fascial layers. It subsequently healed leaving a large ventral hernia. On November 17, an abdominal puncture was performed, and 1,500 cc. of a thick, viscid,

greenish-yellow and odorless pus was withdrawn without any difficulty. This pus showed type I pneumococcus. She was given blood transfusions on several occasions. Her stools still contained ova of the Schistosoma mansoni (26 in 5 slides), and occasional ova of the Trichuris trichura and hookworm, and one cyst of the Entamœba coli. On November 29, 1933, she had a thoracotomy for an empyema on the right side, and on December 14, 1933, a thoracotomy for empyema on the left side.

The sputum, blood, abdominal pus and the pus from both empyema cavities were positive for type I pneumoncoccus.

The child made a slow recovery and was discharged on March 7, 1934, with a ventral hernia. The repair of the hernia was postponed until a later date because of her long protracted and complicated illness.

CASE II. Mrs. M. S., age forty-two. grava II, para II, was admitted to the Gynecological Division on June 4, 1939, with a diagnosis of a possible ruptured ectopic pregnancy or a twisted ovarian cyst. There was no history of any vaginal discharge. Her last menstrual period, which was more profuse and lasted longer than usual, ended three days previously, but on the following day she again commenced to bleed and was still spotting at time of admission. She was awakened at 2 A.M. (eight hours before admission) by severe pain in the lower portion of the abdomen. This pain was relieved by drawing up her thighs and legs. She vomited twice and had two loose stools before admission.

Abdominal examination revealed marked rigidity of the entire abdomen with tenderness and rebound tenderness in both lower quadrants. Vaginal examination disclosed no evidence of any discharge, but there was exquisite tenderness in the right lower quadrant when her cervix was moved. Examination of her throat, heart and lungs was negative.

She was operated upon a few hours after admission for the above named diagnosis, but when the abdomen was opened a large quantity of creamy pus was found free in the abdominal cavity and a large pelvic abscess was present. This abscess in the posterior cul-de-sac was drained and the abdominal fluid was cultured and smears made. Type III pneumococcus was found and the patient was given large doses of sulfapyridine immediately postoperatively. She developed a draining sinus from the lower angle of the wound and was discharged to the out-patient department with it still draining

on July 22, 1939. On September 23, 1939, she was readmitted to the hospital because of an abscess of the abdominal wall which had formed near the draining sinus. An operation under local anesthesia evacuating the abscess and exposing the sinus tracts was performed. The sinus tracts were packed with iodoform and the patient treated with heat under a cradle. She was discharged from the hospital on November 18, 1939, on her fifty-ninth day with all wounds healed.

On March 4, 1940, (three and one-half months later) she was readmitted with bilateral tubo-ovarian abscesses and an external draining sinus in the right lower quadrant. She was operated upon ten days later, when upon opening the abdomen all the intestines and the pelvic structures were found adherent. The adnexa on each side formed two large abscesses, each the size of a grapefruit. The sinus tract was dissected out and a bilateral salpingo-oophorectomy was performed and a drain placed in the posterior cul-de-sac. Postoperatively the patient developed a fecal fistula. She was given a blood transfusion on March 28, 1940. Thereafter she developed pain in both low thoracic regions with signs of bilateral hypostatic pneumonia. She was again given sulfapyridine therapy. On April 26, 1940, she was operated upon for empyema. The culture from the abdominal pus was type III. Her condition failed to improve following the thoracotomy, and she died on May 2, 1940, eleven months after her first admission.

CASE III. *Diffuse Pneumococcic Peritonitis.* Mrs. M. D., age forty-one, a widow, grava III, para I, was first seen by me on February 8, 1940, when she came to my office complaining of marked pain about her vagina and of being "unusually nervous." Her past history revealed that she had had two miscarriages (five months and two months) and subsequently had a full term pregnancy, the child now being nine years old. At this delivery she had a severe tear and a deep episiotomy which required considerable repair. She had had menorrhagia, metrorrhagia and dysmenorrhea for several years and recently this condition had become worse. She also gave a history of exposure two weeks prior to onset of pain.

Three weeks before, she developed pain about her vagina, which was accentuated by a sitting posture, and for two weeks, she had had profuse vaginal discharge. Her menses usually were of fourteen days' duration but her last period was only nine days in duration, beginning January 23, 1940. She had felt unusually tired and nervous and had been quite depressed, suffering occasionally from dizzy spells and suboccipital headaches.

Physical examination revealed a middle-aged, white woman with face flushed, motions nervous, weight 126 pounds, temperature 99°F. and blood pressure 150/80. Her throat was inflamed and there was a slight postnasal drip; the pulse was 72, and the lungs and heart were normal. Vaginal examination disclosed that the uterus was normal in size, shape and position. There was no tenderness or fullness in the right or left fornix, but there was a thick discharge with some necrotic tissue in the posterior fornix, with an area of slight erosion about a scar in the cervix. The urinalysis showed 100 white blood cells per high powered field with fifteen to twenty clumps of pus cells, an occasional red blood cell and a trace of albumen. A cervical smear revealed a large number of pus cells and epithelial cells and a small number of staphylococci, micrococi-catharrhalis and smegma bacilli. A mild cleansing douche and a urinary antiseptic were prescribed and the cervical erosion cauterized.

Ten days later the patient appeared at my office and stated that she felt considerably improved, but that she still had some pain about her vagina, which, as previously, was worse when she was seated. Examination showed some improvement in her condition.

One week after this visit and two-and-a-half weeks after the first visit, she was suddenly seized in the middle of the night with severe generalized abdominal pains of a colicky nature. These pains continued for several hours and were accompanied by nausea, vomiting, fever and the passage of three or four fairly loose stools that seemed as though they were "boiling hot." She had no chills nor any dysuria. Her general appearance was that of a person in severe pain. The rectal temperature was 103.4°F. The abdomen was tender, rigid, distended and tympanitic in all four quadrants. She was still menstruating from a period which had begun five days previously and which was accompanied by pains that were unusually severe and cramp-like in character. She gave a history of having eaten some oysters of doubtful color and quality two days previously, and for dinner the night before had partaken of fresh ham. With this history and the sudden onset of such generalized and severe symptoms,

it appeared that she was suffering from an acute gastroenteritis. A hypodermic of morphine and atropine, and an ice bag to the abdomen were prescribed, and she was observed again four hours later. At this time her symptoms and physical signs seemed more advanced and she was advised to seek further treatment in the hospital.

On admission to the hospital her temperature was 102°F. and her white blood count was 33,000 with 91 per cent polymorphonuclears. Her throat was slightly inflamed, the lungs were clear and the heart normal. Her abdomen was generally tender, rigid and distended. Her pain was now located mostly across the middle of her abdomen. She had the desire to defecate and pass flatus, but had been unable to do so for the past twelve hours. Rectal examination and vaginal examination disclosed bilateral tenderness. Shortly thereafter the pain became less intense, but its colicky nature and her nausea and vomiting persisted. She was quite dehydrated and continuous intravenous fluids were given. Prontosil and neo-prontosil medication were commenced and a Wangensteen tube passed. By this time it seemed that instead of a gastroenteritis, she had a diffuse peritonitis that originated from a spread of a possible pelvic inflammatory disease. The x-rays taken on the night of her admission to the hospital were not very enlightening as to her intra-abdominal condition and were reported as follows:

February 25, 1940: Examination of the abdomen in the prone, supine and erect postures showed a fairly even distribution of gas throughout the colon. The sigmoid appeared to be redundant. No evidence of fluid levels was demonstrated, and there was therefore none of the usual roentgenographic signs of a complete mechanical ileus. No evidence of gas or air was demonstrated in the subphrenic spaces.

On the day after admission her white blood count still showed 30,000 cells with 90 per cent polymorphonuclears, and the sedimentation time was rapid (24 mm. in twenty minutes). A smear from the cervical os was again negative for gonococci and her temperature ranged about 101°F. The Wangensteen tube was draining off huge quantities of putrid smelling, greenish-brown intestinal contents, that at times became red in color from the prontosil medication which now was being given only intramuscularly. New x-ray plates suggestive of small gut obstruction were taken and reported as follows:

February 26, 1940: Examination of the ab-

domen in the prone and erect postures showed numerous loops of gas distended small bowel, several of which showed fluid levels when the patient was examined in the upright posture. These signs are suggestive of an obstructing lesion.

These x-rays indicating the probable existence of an intestinal obstruction raised the question as to whether it was a mechanical obstruction or a paralytic ileus from a generalized peritonitis of pelvic inflammatory origin. An operation scheduled for this day (i.e., day after admission) was postponed because her condition seemed to improve slightly and because it did not appear that she had a mechanical obstruction. The following morning, however, her distention had increased and was localized mostly in the right upper quadrant and it was feared that she might possibly have a mechanical obstruction in her small intestines. A laparotomy now seemed to be indicated. Consequently, under cyclopropane-oxygen anesthesia a laparotomy was performed forty-eight hours after the onset of the acute attack.

The abdomen was opened by a right rectus incision. There was relatively no free fluid in the abdominal cavity, but all the visible organs were covered with a thick, odorless, creamy, seropurulent exudate. All the loops of the small intestines were plastered together with a fibrinous exudate and adhesions, which had formed remarkably early for the type of infection present. There were no dilated loops of gut and the intestinal surfaces were shiny and lacked the customary redness present in peritonitis. The pelvic organs were visualized with difficulty; the uterus had a small subserous fibroid on its posterior surface and the left tube was slightly enlarged and adherent to the uterus. There seemed to be no greater peritoneal reaction or amount of exudate in the lower abdomen than in the upper abdomen. The gallbladder and stomach appeared normal. Smears and cultures were made from the exudate. The obstruction, in the absence of any distended loops of intestines, was believed to be due to a paralytic ileus. The abdomen was closed without drainage by four through-and-through sutures and by the tier method with interrupted chromic catgut sutures.

The abdominal smear showed Gram-positive diplococci and the culture and typing were positive for type XXVIII pneumococcus. The prontosil medication was stopped shortly after operation and 5 Gm. of sodium sulfapyridine were given and later supplemented with sulfa-

pyridine by mouth. Two days later the white blood count had fallen from 30,000 to 9,400 and the polymorphonuclears showed a shift to the left of 24 per cent. Monocytes were present in 8 per cent as well as megaloblasts and many nucleated red blood cells. At no time did the Marshall test show a concentration higher than 7 per cent. Because of the abnormal and young forms of cells present in the blood, this medication was discontinued temporarily on March 2nd, four days after operation. Three days later it was again given for a period of forty-eight hours, in the hope of keeping the exudate thin and preventing the common complication of a secondary pocketing and abscess formation. The patient received two transfusions of 500 cc. each of citrated blood and was kept on continuous intravenous fluids for several days. The Wangensteen tube drained freely the first four postoperative days and was then removed without any discomfort to the patient. The abdominal distention continued for over two weeks but gradually subsided. On the seventh postoperative day the patient had a tremendous watery stool and from then on evacuated normally. The wound healed cleanly and apparently firmly and the patient was allowed out of bed on her sixteenth postoperative day and discharged from the hospital on her twenty-first day with a normal blood count. Following her return to her home her convalescence remained uneventful, and a follow-up sixteen months later revealed her to be symptom-free and in good health.

The operation in this case, established the diagnosis and permitted the use of the proper medication with adequate dosage of sulfapyridine. The administration of the sulfonamides are believed to be accountable for the avoidance of the not uncommon complication of a secondary pelvic abscess as well as her complete and uneventful recovery.

SUMMARY

Three cases of diffuse pneumococcic peritonitis occurred among the last 70,100 admissions to St. Vincent's Hospital. Of 2,280 cases of pneumococcic pneumonia only one patient developed a pneumococcic peritonitis. This patient was treated with type I antipneumococcic serum. Her illness occurred prior to the use of chemotherapy in the treatment of pneumonia.

Absolute diagnosis can be made only by culture of the abdominal pus obtained either by laparotomy or abdominal puncture. The latter procedure should only be performed early in the disease before intestinal adhesions occur as a result of the fibrinous exudate.

Chemotherapy with the proper sulfonamide is indicated as soon as the diagnosis is made. Serum of the proper type should be given as well as the azo dyes, in cases which do not respond quickly.

Surgery is contraindicated unless an intra-abdominal abscess occurs. Before closing the abdomen about 12 Gm. of sulfapyridine should be scattered over the involved area.

The intraperitoneal injection of sulfapyridine or antiserum or both, although not used in any of the cases here reported, appears to be of value and worthy of consideration in the future.

For the past ten years the condition has become less common among young girls. Two of the three cases herein reported were in married women in their fourth decade, and one in a girl of twelve years of age.

The mortality of cases reported in the literature prior to the use of the sulfonamides varied between 58 and 86 per cent.

The mortality in these three cases of diffuse pneumococcic peritonitis was $33\frac{1}{3}$ per cent. The one death occurred after the patient developed pneumonia of a different type and subsequently was operated upon for empyema.

REFERENCES

1. BARRINGTON-WARD, SIR LANCELOT. Brit. M. J., 2: 704–706, 1932.
2. BARRINGTON-WARD, SIR LANCELOT. Practitioner, 142: 367–374, 1939.
3. BASS, MURRAY H. Med. Clin. North America, 19: 847–855, 1935.
4. DORAN, WM. T. and ALLEN, PHILLIP. Personal communication, 1941.
5. HORINE, C. F. Ann. Surg., 102: 391–394, 1935.
6. KING, J. E. Pneumococcic pelvic infections in adults. J. Obst. & Gynec., 29: 341–349, 1935.
7. OBADLER, W. Deutsche Ztschr. f. Chir., 233: 581, 1931.
8. SCARAVELLI, C. Six cases with advantage of early intervention and injection of anti-pneumococcus antiserum. Policlinico, 42: 979–986, 1935.
9. SCHONENBERGER, EMIL. Basil Thesis, 1929.

CRANIAL CHORDOMA*

REPORT OF A CASE IN WHICH SURGICAL INTERVENTION WAS SUCCESSFUL

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ONLY lately have reports begun to appear concerning successful palliative surgical attack on cranial chordoma. Gardner and Turner[1] in a recent excellent article have summarized our present knowledge of the subject and reported three cases of their own.

Because we have seen three cases† within the past six months, in one of which the patient was operated upon with at least temporary recession of symptoms, it would appear that the disease is not as rare as had been previously considered; and we hope that the recording of an additional case in which the patient was benefited by surgery may serve to re-emphasize a condition which has usually been considered more or less refractory to surgical attack.

CASE REPORT

Mrs. H., a rather pleasant, somewhat obese, mentally alert, female of forty-seven was first seen by one of us (J. H. W.) on August 4, 1939, at which time she complained of earache, deafness, tiredness and loss of twenty-five pounds in weight. At this time the most persistent complaint was deafness of the left ear which she believed was due to something obstructing the left ear canal.

On examination the patient showed some edema of both posterior faucial pillars and moderate redness of the throat, for which she was referred to an otorhinolaryngologist. He treated her eustachian tubes locally for several days with apparently excellent results. A basal metabolic rate done at this time was minus twenty-six. The urinalysis showed a slight trace of albumin. Estimation of hemoglobin by the Haden method was 76 per cent. The red cells were 4,120,000 and the blood sugar was 91 mg. per cent. Because of these findings the patient received Burroughs-Wellcome thyroid extract, gr. 5 daily for approximately one hundred days.

She was next seen on December 17, 1940, at which time she was admitted to St. Luke's Hospital with a complaint of marked photophobia of the right eye. The left eye was totally blind, having been so at least several months prior to August 1939. Her teeth had been x-rayed and had been found not to be faulty. The patient stated at this time that she had been having severe headaches which sometimes awakened her at night and almost always were present on awakening in the morning, and that these had become so severe that she was forced to enter the hospital.

Neurologic examination at this time disclosed the following findings:

Ophthalmoscopic examination revealed that the right optic nerve head was extremely pale, graded plus two on a basis of one to four. The left optic disc was completely atrophic. Examination of the visual fields revealed an upper temporal quadrantic defect in the right eye and complete blindness in the left. The left eyelid drooped somewhat, and there was a manifest external strabismus due to paresis of the left third and sixth cranial nerves. Ocular movements of the right eye were normal. The left eye was essentially immobile in all planes. The pupils were large and equal, both round, and the right reacted to light and accommodation while the left was unreactive. The left

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† Two of these cases with necropsy studies will be reported later in another communication by Dr. Victor Buhler and associates from the Kansas City General Hospital.

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eye was noted to be somewhat more prominent than the right in spite of the presence of ptosis of the left lid. The sensation in the right half

FIG. 1. Left lateral view showing dispersed areas of suprasellar calcification extending into the left middle fossa and destroying the posterior clinoid processes, dorsum sellae, clivus and left sphenoid wing.

of the face was normal, but on the left there was a subjective diminution in the appreciation of touch and pin prick over the distribution of the fifth cranial nerve. There was no dysfunction of the seventh cranial nerve, and the hearing was depressed in the left ear. The palate was freely movable and there was no dysfunction of swallowing or breathing. The sternomastoid and trapezius muscles functioned well bilaterally.

In appraisal of the reflexes, it was noted that there was a subjective diminution of the corneal sensation of the left eye. The reflexes in the upper extremity were normal and symmetrical, and pyramidal tract signs were absent. Likewise, examination of the reflexes of the lower extremity and abdomen yielded physiological results.

In view of these findings, it was assumed that the patient was suffering from a retrobulbar or retro-orbital mass lesion and consequently x-rays of the cranium included the orbital fissures and optic canals. X-rays disclosed the presence of a large, irregularly calcified lesion in the left middle fossa which had caused almost complete destruction of the sella turcica, posterior clinoid processes and had eroded and enlarged the left orbital fissure and left sphenoid wing. (Fig. 1.)

The past history of this patient is of considerable interest inasmuch as it conforms very well to the pattern of many cases previously reported in the literature. In 1934, the patient began gradually to have a rather creepy sensation running up the left side of her face. This was said to have occurred about every day or every other day and would last only a few seconds. At this time she had three or four terrible headaches which awakened her at night. The patient was unable to give any intervening history between 1934 and July, 1937, at which time she consulted an oculist because of some visual disturbance and photophobia, principally in the left eye. At that time she had a medical examination which disclosed nothing. Again in the fall of 1937 the patient consulted her oculist who gave her ocular exercises. At that time one of the doctors remarked that the left third nerve was paralyzed. However, she had not at that time noted diplopia. After three months of ocular exercises, she continued to have visual difficulty in her left eye. It was then recommended that she have an extraction of a tooth which resulted in a cessation of the parasthetic symptoms over the left side of her face for about a year.

In 1938, however, the parasthesia of the face returned and again a tooth was extracted with cessation of symptoms. She remembers distinctly that she could see somewhat with the left eye at this time. The teeth and sinuses were again x-rayed and on a basis of these x-rays a tonsillectomy was advised. This, however, was not carried out. In the fall of 1938 she consulted an ophthalmologist who gave her a prescription containing potassium iodide. This made the patient quite sick and she discontinued its use immediately.

In 1939, the patient was definitely blind in the left eye. The development of blindness had been so gradual that she did not know definitely when she lost her vision, but she is quite firm in believing that after blindness developed, she could see much better with the right eye.

During the early part of 1940, she had left frontoparietal headache often, but this was not an excruciating type, although occasionally

Fig. 2. Low power photomicrograph showing a typical area in the tumor. Note the matrix, tumor cells and fragile blood vessels.

severe enough to awaken her during the night. If she got up and walked about the house, the headache would stop. There was no associated nausea or vomiting.

In the early part of December, 1940, the headaches had become so severe that the patient was considerably discomforted by them and awakened at night almost continually. It was because of this symptom of headache that the patient finally was admitted to the hospital.

Operation. On January 8, 1941, under intertrachial ether anesthesia, a large osteoplastic flap was reflected in the left temporal region, exposing the dura, which was incised and reflected, revealing the cortex of the left temporal lobe with the convolutions greatly broadened and flattened. To the palpating finger the cortex was quite firm, and exploring the cortex with the cannula the surgeon found that resistance was encountered at the depth of 1 cm. The middle temporal convolution was then incised, exposing a tough, slick, firm, whitish membrane beneath the cortex about the depth of 1 cm. Upon incision of this tough membrane, the tumor tissue oozed out spontaneously, the tissue being composed of a gelatinous like substance, of a somewhat dirty, whitish gray to red color.

The incision through the capsule was thereupon enlarged, and the tissue mass removed chiefly by suction. After a considerable amount of the neoplastic tissue was so removed, large islands of more condensed and calcified tissue were removed by the use of pituitary forceps. After removal of all the neoplastic tissue, the middle fossa was bared, the left optic nerve and carotid artery were exposed, the back of the orbit and sphenoid wing being absent, allowed ready access to the left orbit from which large quantities of tumor tissue were removed. The left optic nerve was one-half its normal size. The tumor could be seen extending posteriorly across the petrous ridge. All the tumor tissue which could be seen was removed, and after hemorrhage was controlled, the wound was closed in the usual manner.

Postoperative convalescence was essentially uneventful. Surprisingly enough, the patient showed only a mild degree of disturbance of speech. She was dismissed from the hospital about twelve days following her operation. Up to the present time the patient has suffered only the inconvenience of moderate mal occlusion of the teeth because of affectation of the left pterygoid muscles. The patient is bright and alert and subsequent examination of the perimetric field has shown that the vision of the right eye is greatly improved.

The patient was last examined January 5, 1942, approximately one year after her operation. At this time she seemed quite bright, alert and able to carry on the usual duties of a housewife. Her visual field defect of the right eye had expanded considerably, the visual acuity being 20/20 in the right eye. The patient on this date showed no neurologic evidence of recurrence, and the small decompressed area in the left temporal bone was flaccid and pulsating.

Gross Pathology. The material removed at operation was a reddish, mucinous, soft sticky mass from which impression smears could be obtained readily. It resembled nothing so much as the mucin of a soft mucoid carcinoma. In addition there were many varying sized fragments of bone and calcific material.

Histologic Pathology. Impression smears were made at the operating table and stained with toluidine blue. These preparations revealed at once the true character of the neoplasm.

With paraffin sections stained with hematoxylin and eosin, a stringy, deeply blue staining, mucinous matrix was observed which enmeshed long columns and nests of oval and rounded sharply defined tumor cells with a sharply defined basophilic cytoplasmic border. The cytoplasm of these cells was faintly pink or orange staining and often granular in character. The nuclei were small, round or oval and stained basophilic. (Fig. 2.) In some areas the cells somewhat suggested young embryonal cartilage cells.

The vascular supply of the tumor was quite abundant. The vessel walls were usually poorly preserved. The very delicate, mushy, gross character of the growth may have been responsible for the fact that the walls of the majority of the vessels were fractured. Often masses of orange to pink staining tumor cells and mucinous blue matrix were seen penetrating the lumena of the vascular channels. Aside from the bluish matrix very little to suggest any type of stromal element could be made out in any of the sections. Sometimes about the blood vessels a fairly homogeneous, almost acellular orange staining substance was seen which contained a few orange staining chordoma cells. At times tiny columns of spindleform connective tissue elements were seen in the vessel walls. Several of the bone fragments were sectioned, and they showed actual erosion and invasion by chordoma cells with their accompanying basophilic matrix.

Masson's trichrome, Best's carmine, and Cajal's uranium nitrate stains for Golgi apparatus were all employed on paraffin embedded sections.

The tumor cells contained large amounts of glycogen granules, and in all respects followed the histological characteristics of chordoma.

COMMENT

In 1934, Hass[2] collected twenty-five cases of cranial and cervical chordomas in which surgical removal had been attempted without much success, the tumor recurring usually within six months to a year and a half. Nevertheless, cases recorded by Klotz[3] and Bailey and Bagdsar[4] mentioned that the patients lived four and one-half and five years, respectively, after surgical intervention, and there are several cases on record in which temporary benefit has been observed after attempted removal of the growth.

The clinical and roentgen findings in our case are quite classical, since a great many of the recorded characteristic features of this neoplasm were present, namely, multiple, consecutive, unilateral, cranial palsies resulting from a middle fossa mass lesion with x-ray evidence of erosion of the sella and beginning penetration of the maxilla.

At operation an apparently well encapsulated tumor was found involving the left anterior cranial nerves, and the mucinous-like character of the growth when the capsule was removed was almost diagnostic of the condition.

CONCLUSIONS

Cranial chordomas are not unusually rare. They are sometimes amenable to surgical interference and very often considerable clinical improvement may follow such interference. The presence of a middle fossa lesion with multiple cranial nerve palsies and x-ray findings of destruction of the clivus is highly suggestive evidence that the growth may be a chordoma.

An instance of such a tumor occurring in a forty-seven year old female, who was

strikingly benefited at least temporarily by surgical intervention is recorded.

REFERENCES

1. Gardner, W. J. and Turner, O. Cranial chordomas: a clinical and pathologic study. *Arch. Surg.*, 42: 411, 1941.

2. Hass, G. M. Chordomas of cranium and cervical portion of the spine: review of the literature with report of case. *Arch. Neurol. & Psychiat.*, 32: 300–327, 1934.

3. Klotz, A. Chordome malin du nasopharynx. *Semaine d. hôp de Paris*, 7: 56, 1931. (Quoted from Gardner and Turner.)

4. Bailey, P. and Bagdasar, D. Intracranial chordoblastoma. *Am. J. Path.*, 5: 439–450, 1929.

The essential factor of the diffuse acute goiter is its rapidity of onset. The diffuseness has to do with the gross anatomy, that is, both lobes are uniformly enlarged. Bilateral uniform enlargement of the gland with an acute onset of the symptoms of thyrotoxicosis establishes the diagnosis. From—"Diseases of the Thyroid Gland. Presenting the Experience of More Than Forty Years"—by Arthur E. Hertzler (Paul B. Hoeber, Inc.).

POSTOPERATIVE GANGRENE OF THE FINGER
FOLLOWING DIGITAL NERVE BLOCK ANESTHESIA

REPORT OF A CASE

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GANGRENE of the finger following digital nerve block anesthesia is frequently mentioned as a complication of this very common surgical procedure. That it occurs very rarely is supported by the infrequent reports in the literature in spite of its wide general use. The following case is reported to emphasize certain of the hazards which must be considered when digital nerve block anesthesia is employed:

CASE REPORT

M. S., a man, fifty-two years old, was seen ten days after the development of a tender, red area at the base of the nail on the right middle finger. Examination disclosed a typical paronychia involving the base and the radial side of the nail. Surgical drainage under block anesthesia was advised.

The middle phalanx of the finger was blocked, using 2 per cent novocain with adrenalin, a total of 3 cc. being employed. The finger was seen to blanch temporarily following the injection but the color promptly returned with massage. A rubber band tourniquet was applied about the base of the digit five minutes after the novocain was introduced to provide a dry field during the operative procedure. This consisted of the usual bilateral incisions at the base of the nail with removal of a portion of the nail root. A piece of rubber dam was introduced beneath the skin flap and the tourniquet immediately removed. The operation required approximately five minutes and the tourniquet was in place only during that period of time. A small amount of bleeding occurred when the tourniquet was removed. This was encouraged by gentle massage of the proximal and middle phalanges. Warm boric acid soaks were advised for the postoperative period.

The patient immediately returned home and after preparing a boric acid solution proceeded to saturate the dressings. The temperature of the solution was not tested and apparently the finger was immersed in very hot boric acid while the digit was still anesthetized. Severe pain developed in the finger within twelve hours and persisted until the patient again reported, forty-eight hours after the operative procedure.

Examination disclosed the entire distal phalanx to be dusky and anesthetic. There was a large bullus on the dorsum of the finger extending from the base of the nail over the dorsum of the middle phalanx. The blister was cut away and all the superficial skin of the tip of the finger, including the nail, was easily removed in one piece. The underlying tissue of the finger tip was bluish-black and definitely gangrenous.

The finger was treated conservatively and in twelve days a definite line of demarcation was apparent at the junction of the middle and distal phalanges. The tissue on the dorsum of the middle phalanx remained viable, having sustained only a second degree burn.

Two weeks after the original operation the patient was admitted to the hospital and the finger amputated under gas-oxygen anesthesia. A circular incision was made just proximal to the line of demarcation, the bone of the mid-phalanx being divided at the junction of its middle and distal thirds. The flaps were loosely approximated and the tip permitted to close by second intention. Healing was complete and the patient back at full work five weeks after the amputation.

Examination during the period of hospitalization disclosed no evidence of peripheral sclerosis. Blood studies and urinalysis were normal, and the Kline and Kahn reactions were negative.

One year later the patient again reported with a paronychia on the right index finger. This was opened under block anesthesia, using .5 per cent novocain without adrenalin. The

patient was kept in the hospital for a period of two days so that the postoperative treatment could be carefully supervised. Convalescence was entirely uneventful in this instance, demonstrating an absence of any specific sensitivity to novocain.

DISCUSSION

Kaufman,[2] in a recent review of the cases of gangrene following digital nerve block anesthesia, found only one previous report of four cases in the American literature. He collected a series of twenty-five cases from the European literature, and these with the four cases reported by Garlock,[1] and one observed by himself, brought the total number to thirty. Our patient brings this total to thirty-one cases, of which only six have been reported by American observers. One cannot but doubt that this small series represents a true index of the frequency of this complication.

The contributing factors in the development of this unfortunate complication have been listed as follows: peripheral arteriosclerosis, allergic reaction to the anesthetic agent, the injection of excessive amounts of solution, vasoconstriction due to epinephrin, vascular trauma incident to the tourniquet and burns from immersing the anesthetized finger in abnormally hot solutions.

Each of these factors, or a combination of several, are sufficient to produce gangrene following digital nerve block anesthesia. In the case here reported there is little doubt that the burn from the excessively hot boric acid solution precipitated the gangrene. This was true in Kaufman's personal case and in one other in his collected series.

It is important to remember that nerve block anesthesia is a procedure that is not entirely free from danger. Small amounts of .5 or 1 per cent novocain without epinephrin should be employed and the solution injected in close proximity to the digital nerves. Tourniquets are to be avoided prior to injection, and if used to obtain a bloodless field, their application should be limited to the shortest possible period. Free bleeding should be encouraged by massage at the end of the operative procedure. When hot packs are desirable during the postoperative period, they should not be employed until the anesthesia has entirely disappeared. The temperature of the solution should be very carefully controlled by testing it on intact healthy skin. When feasible it is desirable to reexamine all patients subjected to this type of anesthesia within two hours after the operation so that the circulation of the digit may be determined and prophylactic therapy instituted when necessary.

SUMMARY

A case of postoperative gangrene of the finger following digital nerve block anesthesia is reported. The recent literature on this subject is reviewed, stressing the relatively small number of these cases present in the American literature. The injudicious use of abnormally hot, wet dressings following the use of local anesthesia is stressed as a frequent cause of this complication.

REFERENCES

1. GARLOCK, J. H. Gangrene of the finger following digital nerve block anesthesia. Ann. Surg., 94: 1103–1108, 1931.
2. KAUFMAN, P. Gangrene following digital nerve block anesthesia. Arch. Surg., 42: 929–939, 1941.
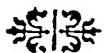
UNUSUAL METASTASIS OF RECTAL CARCINOMA

CASE REPORT

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VIRCHOW'S node is the lymph-node or group of lymph-nodes behind the clavicular insertion of the left sterno-mastoid muscle. It is near the termination of the thoracic duct at the junction of the left subclavian and internal jugular veins. In 1849, Virchow[1] called attention to the fact that metastatic growth develops occasionally in these lymph-nodes in carcinoma in the abdominal cavity. In doubtful cases of abdominal tumors, such secondary localization might be of great diagnostic value. Wood[2] stated that secondary localization in these lymph-nodes is rare with cancer of the stomach and that metastases to the left supraclavicular space in patients with adenocarcinoma of the rectosigmoid are even more rare.

In reviewing 366 cases of malignancy of the lower bowel, Bacon[3] found evidence of metastasis to one or more distant organs in 126 instances. None of this group presented involvement of the supraclavicular lymph-nodes. Buie[4] quotes Broders as stating that he had not seen a case of metastasis to Virchow's node from a carcinoma of the rectum but that the supraclavicular metastasis from such a primary focus can occur. Because of the paucity of reports in the literature of such a sequence of events, the following case report warrants presentation:

CASE REPORT

A fifty-one year old white man was first seen January 5, 1940, because of intermittent rectal bleeding, abdominal cramps and diarrhea of short duration. About two months before he came under observation he began to complain of abdominal cramps which occurred at frequent intervals daily. The cramps were of short duration and were located in the lower portion of the abdomen. The patient had been consti-pated for many years but since the onset of the abdominal cramps he had had a change in his bowel habits. About one month prior to the time he first came under observation, he had a small watery stool with each spasm of cramps. There was an indefinite loss of weight. He continued to work but complained of feeling tired before the end of his working day.

The past history is significant because of the fact that in 1937 the patient complained of protruding, painful and bleeding hemorrhoids. He complained of constipation and with each bowel movement, he noted protrusion of hemorrhoids. He had some rectal bleeding prior to this time and had lost five pounds in weight between January, 1937, and May, 1937. Anoscopic examination preceding the hemorrhoidectomy performed by a surgeon revealed several internal varices. He was discharged from a hospital on May 12, 1937, nine days following a hemorrhoidectomy.

The pertinent findings in the physical examination in his last illness were marked pallor, poor nutrition and loss of skin elasticity. The blood pressure expressed in mm. of mercury was 130 mm. and the diastolic blood pressure was 80. There was a small, firm, discreet, bean-sized nontender gland palpable in the left supraclavicular fossa at the sternoclavicular junction. The liver and spleen could not be palpated. There was a loss of adipose panniculus of the abdominal wall. A group of glands about the size of pigeon eggs could be felt along the mesentery. Fluoroscopic study of the chest revealed normal lung findings. There was no exaggeration of the mediastinal or hilar lymph-nodes. The heart was centrally placed. There were no abnormalities noted in the contour of any of the cardiac chambers or borders. The barium meal was seen to flow through the esophagus freely. There was a very short delay in the passage of the barium through the cardio-esophageal junction. The stomach filled in the normal manner. The outline of both curvatures of the stomach was smooth. Normal

peristaltic waves were seen to progress in normal fashion to the pyloric region. The duodenal cap was observed to fill out and empty

Laboratory data revealed the following: hemoglobin (Sahli) 78 per cent, 4 m. ery- throcytes, 47 per cent polymorphonuclear
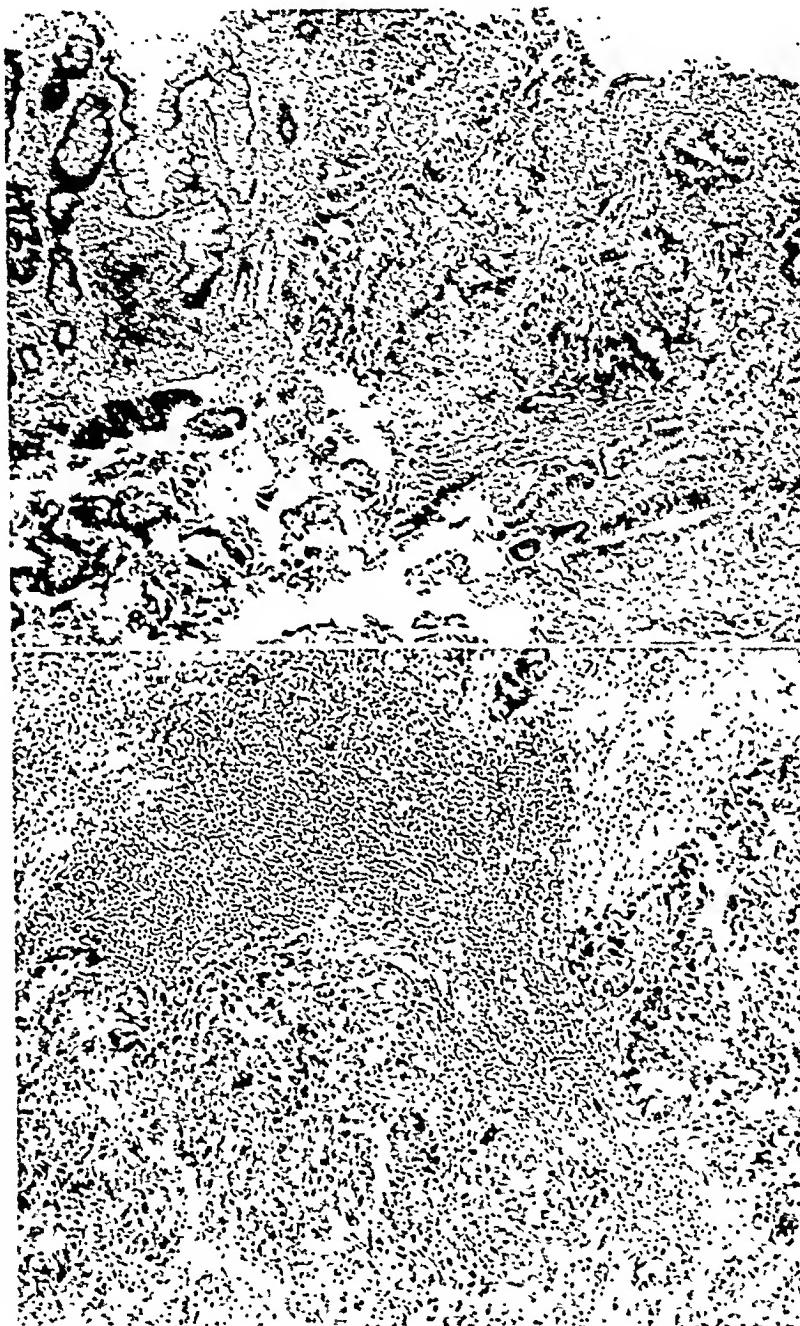
FIG. 1.

FIG. 2.

FIG. 1. Fragment of tissue removed from rectum reveals tumor tissue arising from the mucosa and invading diffusely into the underlying submucosa. × 100.

FIG. 2. Section through left supraclavicular node reveals metastatic infiltration of tumor cells of a type similar to that noted in the rectal biopsy. × 150.

normally. There were no gastric, pyloric or duodenal irregularities or abnormalities demon- strable fluoroscopically. These examinations were made in an attempt to visualize a primary malignant gastric focus.

leukocytes, 48 per cent lymphocytes, 5 per cent eosinophilic leukocytes. The sedimentation of the erythrocytes was 18 mm. in fifty-five minutes. The blood Wassermann reaction was negative. The urine was normal. Procto-

sigmoidoscopic examination performed by Dr. Robert Turell revealed mixed piles. A large papillary mass about 14 cm. from the anal orifice occupied the anterior surface of the colon. Several fragments of the tumor tissue were removed from the rectum for histologic study.

The microscopic appearance (Fig. 1) of this tissue was as follows: "Sections of the fragments of tissue removed from the rectum reveal tumor tissue arising from the mucosa and invading diffusely into the underlying submucosa. Here and there abrupt transitions of the normal mucosa into the neoplastic tissue are seen. The tumor is composed of highly irregular glands lined by single or stratified layers of hyperchromatic columnar cells which in many places show evidence of changed polarity. Mitotic figures are numerous. There are scattered polymorphonuclear leukocytes, eosinophiles and lymphocytes in the submucosa."

Subsequently the patient was sent to The Brooklyn Hospital where the supraclavicular glands were removed by Dr. R. Turell. The pathologic reports were rendered by Dr. J. Arnold de Veer. The microscopic appearance (Fig. 2) of these glands was as follows:

Sections through the supraclavicular lymphnodes reveal them to be imbedded in and partially replaced by fibrous tissue showing chronic inflammation. The lymph-nodes are occupied, too, by metastatic tumor with a pattern quite like that of the tumor in the rectum. There are highly irregular glands and solid nests of hyperchromatic columnar cells showing occasional mitoses and often surrounding cores of necrotic tissue. Tumor emboli are seen frequently in the periarterial lymphatics in the vicinity of the capsule of the lymph-nodes.

The patient's condition was poor. There was evident cachexia and dehydration. Operative intervention was suggested but refused. The patient's course was rapidly downhill. He died fourteen weeks after he came under observation. Necropsy was refused.

DISCUSSION

In order to attempt an explanation of the formation of a Virchow node in patients with carcinoma of the rectum, a review of the lymphatics of the rectum was made. According to Rouviere[5] the rectum possesses the same mucous, submucous and muscular networks as the other parts of the large intestine. Nevertheless, the rectal mucous network presents certain peculiarities; it differs, in the pelvic part of the rectum, in the pars analis recti and in the cutaneous zone below the anal valves. The mucous lymph network is more developed in the rectal than in the anal parts of the rectal mucosa. The continuity of the lymphatic network of the rectum throughout its entire extent explains why the inguinal nodes, which become swollen in cancer of the anus, may also become affected when the cancer is situated higher up. Superiorly, the mucous network of the rectum is continuous with that of the sigmoid colon; but the meshes of the network on the colic side are much larger. In the cutaneous zone below the anal valves the mucous and submucous networks are replaced by a dermal and subcutaneous lymphatic network, both consisting of a very compact meshwork. The dermal lymphatic network is particularly dense and is continuous above with the mucous lymph capillaries of the anal canal, and below with the perineal cutaneous lymphatic network of the gluteal region.

Looney[6] has demonstrated anatomically that the lymphatic system about the rectum and anus is divided into three collecting trunks: an inferior, middle and superior.

The inferior collecting trunk corresponds to the anal integument, in which the capillary networks, both superficial and deep, are extremely abundant and from which three to five collecting vessels on either side pass to the inguinal region and end in the medial superficial inguinal nodes.

The middle zone corresponds to the transition zone of the epithelium, that is, with the mucous membrane below the columns of Morgagni. Here the network is coarse and has its meshes arranged vertically, its ducts drain partly into nodes situated along the inferior and middle hemorrhoidal arteries, and partly pass to the nodes of the mesorectum, situated

along the superior hemorrhoidal artery and known as the anorectal nodes.

The superior zone corresponds to the remainder of the rectal mucous membrane and contains a rich network whose collecting vessels pass to the anorectal glands and thence along the superior hemorrhoidal artery to the mesocolic and inferior mesenteric nodes. These routes form the lymph channels described by Miles[7] as the extramural lymphatics into which the intramural and intermediary systems drain.

The intramural lymphatics consist of two freely communicative networks located within the wall; one, the submucosal, and the other, the intermuscular. These intercommunicate by radial lymph channels lying between the circular fibers. The submucosal network is to a lesser extent continuous above with the pelvic colon, and below with the subcutaneous lymph channels of the perianal skin. The main avenue of dissemination, according to Coller[8] and his associates, is through the external muscle coat to the intermediary system.

Lymph drainage differs from vascular drainages in that there may be several efferent vessels to a single node. Gilchrist[9] is of the opinion that lymphatic spread is primarily embolic. Lymph-nodes involved in this manner become blocked and act as a filter to prevent further dissemination of carcinoma cells. Lymph flow becomes static and other embolic foci may be established through collateral unobstructed channels. The direction of the lymphatic metastases depends on the direction of the lymph flow. Thus retrograde transport[10,11] of carcinoma cells may result following occlusion of lymph trunks. The most common channel for widespread dissemination of carcinoma is through the thoracic duct from which cancer cells are poured into the general circulation.

Shafiroff[12] has noted that the thoracic duct in dogs occasionally runs through a lymph-node just before its entrance into the subclavian vein. In these instances the patency of the lymph duct is interrupted by the meshwork of the lymph gland and is re-established after the duct emerges from the node. If this observation in dogs is confirmed in man, it may be a very logical explanation for the formation of the node noted in this case.

An autopsy examination was not made. In view of the entirely negative fluoroscopy of the stomach, it was not believed that the primary focus from which the gland in the neck was formed was from the upper gastrointestinal tract. The mesenteric glands were enlarged as a result of the dissemination of cancer cells from the primary focus in the rectum. The microscopic appearance of the left supraclavicular lymph-nodes resembled very closely the microscopic appearance of the tissue removed from the rectosigmoid. A diagnosis of carcinoma of the rectum with metastasis to the left supraclavicular nodes appeared justified.

SUMMARY

A case of carcinoma of the rectosigmoid with metastases to the left supraclavicular space (Virchow's lymph-node) is reported.

REFERENCES

1. Virchow, R. Die Medizinische Reform. P. 248, 1849.
2. Wood, F. C. Personal communication.
3. Bacon, H. E. Unusual sites of metastasis from carcinoma of the rectum and sigmoid colon. *Philadelphia M. J.*, August, 1940.
4. Buie, L. A. Personal communication.
5. Rouvière, H. Translated by M. J. Tobias: Anatomy of the Human Lymphatic System. Ann Arbor, Mich., 1938. Edwards Press, Inc.
6. Looney, W. W. Lymphatic distribution of the colon and rectum. *Am. J. Surg.*, 46: 143–148, 1939.
7. Miles, W. E. Pathology of spread of cancer of rectum and its bearing upon surgery of cancerous rectum. *Surg., Gynec. & Obst.*, 52: 350, 1931.
8. Coller, F. A., Kay, E. B. and MacIntyre, R. S. Regional lymphatic metastasis of carcinoma of the rectum. *Surgery*, 8: 294–311, 1940.
9. Gilchrist, R. K. Fundamental factors governing lymphatic spread of carcinoma. *Ann. Surg.*, 3: 4, 1940.
10. Gilchrist, R. K. and David, V. C. Lymphatic spread of carcinoma of the rectum. *Ann. Surg.*, 108: 4, 1938.
11. Westhues, H. Die pathologisch anatomischen Grundlagen der Chirurgie des Rektumkarzinoms. P. 78. Leipzig, 1934. George Thieme. Quoted by Colp, R. *Ann. Surg.*, 108: 638, 1938.
12. Shafiroff, B. G. P. Personal communication.

SPONTANEOUS HEMORRHAGE INTO THE RECTUS ABDOMINIS MUSCLE SIMULATING ACUTE INTRA-ABDOMINAL CONDITIONS

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SPONTANEOUS hemorrhage into the rectus abdominis muscle is rare. Cullen,[2] during thirty years of surgical practice, saw only five cases. Several surgeons of wide experience have stated to the author that only a few examples of this condition have come under their observation. It simulates acute intra-abdominal disease so closely that it is rarely diagnosed before operation.

Anatomy. There are several points in the anatomy of the rectus abdominis muscle which deserve emphasis. The posterior aspect of this muscle lacks a fibrous sheath in its lower third, so that a collection of blood could exert considerable pressure against the peritoneum below the semilunar fold of Douglas. The blood supply depends largely on two vessels: The upper is the superior epigastric artery which is a continuation of the internal mammary; the lower is the inferior epigastric artery which is a branch of the external iliac. There is also some blood supply from the intercostal vessels. The epigastric vessels run in a shallow groove on the posterior aspect of the muscle, except at the level of the umbilicus where they meet in the substance of the muscle in a dense capillary and arteriolar network.[5] A double system of veins parallels the arteries.

Etiology. The immediate cause of a hemorrhage in the rectus abdominis muscle may be a slight exertion such as coughing, turning in bed or riding in an automobile over a rough road. Often careful questioning of the patient fails to elicit any specific act or trauma which might have produced the clinical picture. Degeneration of muscle and blood vessels may be the basic factor which is provocative of intramuscular hemorrhage. All of our patients were over sixty years of age. Some febrile diseases are complicated by muscle degeneration. Rudolph Virchow,[6] in 1857, described rupture of the rectus abdominis in typhoid fever and he gave a detailed account of hyaline degeneration of muscle in this disease. Rectus muscle tears were quite frequent during the influenza epidemic of 1918.[4] Hemorrhage into the rectus abdominis may be one of the complications of pregnancy.[1]

Diagnosis. The earliest and most constant symptom is abdominal pain. The location of this pain depends primarily on the site of the hemorrhage. The severity of the pain is usually in direct proportion to the size of the hematoma. The patient may notice an abdominal mass or discoloration of the abdominal skin. The leucocyte count is frequently elevated.

The physical signs depend upon the degree of intramuscular hemorrhage. Only spasticity may be present if a few small blood vessels have ruptured, and a palpable mass presupposes a sizable hemorrhage. Tenderness is quite marked and it is confined to the circumscribed area of the hematoma. The abdominal wall adjacent to the hematoma usually has no tenderness. This is an important diagnostic sign and it should help to exclude an intra-abdominal condition. A large hemorrhage produces a mass which can be felt fixed in the abdominal wall. Absence of the posterior rectus sheath below the semilunar fold of Douglas may allow extravasation of

blood downward anterior to the peritoneum and thus a mass may be palpable through the vagina or rectum. Another significant sign is ecchymosis of the abdominal skin which may be some distance away from the area of tenderness.

Treatment. Operative treatment is indicated. Bleeding points should be ligated when possible and the hematoma evacuated. Operative delay may cause progressive hemorrhage and secondary infection may then complicate the picture. Closure of the wound without drainage is preferable except in those cases in which hemorrhage cannot be completely controlled, when infection has already occurred, and when there is a large dead space.

CASE REPORTS

Case i. J. T., No. 763, a seventy-two year old seaman, was admitted to the second surgical division of Welfare Hospital, New York City, service of Dr. Louis Carp, on July 31, 1940. He had been on the medical ward for one year for the treatment of chronic myocarditis and aneurysm of the abdominal aorta. The patient complained of right lower quadrant pain of fifteen hours' duration which began during the night while he was in bed. There had been no nausea or vomiting. At the time of the surgical consultation his rectal temperature was 100°F., pulse 112, and respirations 20. The blood pressure was 120/70. He appeared acutely ill and in pain. The entire right side of the abdomen was tender, especially at a point just below the level of the umbilicus. Spasm of the right rectus abdominis muscle and generalized rebound tenderness were also present. A large pulsating mass probably aorta, could be felt in the epigastrium. The white blood count was 18,600 of which 78 per cent were polymorphonuclear leucocytes and the remaining 22 per cent lymphocytes. The blood Wassermann test was negative. The urine contained a trace of albumin and five red blood cells per high power field as well as an occasional white blood cell.

A diagnosis of acute appendicitis was made and the patient was operated upon by the author. Cyclopropane anesthesia was used. A 9 cm. vertical incision was made over the lower half of the right rectus abdominis muscle. When the anterior rectus fascia was divided,

there was found just below the level of the umbilicus a hematoma about 4 cm. in diameter containing clotted and unclotted blood. Muscle fibers were torn and macerated, and the intact muscle bundles adjacent to the site of hemorrhage were gelatinous and friable. Several small blood vessels were ligated. The peritoneal cavity was then opened and the appendix was found to be normal. The aorta and iliac arteries were greatly dilated and studded with sclerotic plaques. The abdomen was closed in layers without drainage. The patient's course was uneventful except for extensive ecchymosis around the wound which gradually disappeared within three weeks.

Case ii. Mrs. S. S., No. 220181, was a sixty-two year old housewife who was admitted to the surgical service of Dr. Louis Berger, Jewish Hospital of Brooklyn, on March 9, 1939, with a two-day history of pain and swelling in the lower half of the left side of the abdomen. She had not vomited and her appetite had not been impaired. For many years she had suffered from hypertension, and a year before she had been confined to bed for six months because of a severe "heart attack." She was taking a maintenance dose of digitalis at the time of admission.

Her temperature was 99°F. and her blood pressure 230 systolic and 130 diastolic. She did not appear acutely ill. Her heart was diffusely enlarged and a loud systolic blow could be heard over the entire pericordium. In the left lower quadrant of the abdomen was a mass extending from the midline toward the anterior superior iliac spine and it measured about 10 cm. in diameter. It was firm, tender and somewhat mobile. The vaginal and rectal examinations were negative. She was observed for forty-eight hours and during that time the mass increased in size and ecchymosis appeared around the umbilicus.

Roentgenologic study of the large intestine by means of a barium enema showed no abnormality. There was evidence of serious myocardial involvement on the electrocardiographic tracing. The red blood count was 3,300,-000 and hemoglobin 50 per cent; there were 8,000 white blood cells of which 88 per cent were polymorphonuclears and 12 per cent lymphocytes. The sedimentation time was rapid. The blood chemistry was normal and the Kline test for lues was negative. The urine contained a trace of albumin. No occult blood was present in the stool.

The preoperative diagnosis considered were mesenteric or ovarian cyst. Operation showed a large hematoma in the left rectus abdominis muscle extending from the level of the umbilicus to the symphisis pubis and from the midline outward toward the flank. A large amount of fluid and clotted blood was present. The peritoneal cavity was opened but no intra-abdominal abnormality could be found. The abdomen was closed in layers and the cavity in the muscle was drained through a lateral stab wound. Tissue removed for microscopic examination was reported as clotted blood. The wound continued to drain sanguineous fluid for seventeen days and it was completely healed in twenty days.

CASE III. C. C., No. 23714, was a sixty-two year old Italian laborer who was admitted to the surgical service of Dr. Robert Kennedy, Beekman Hospital, New York, on May 21, 1934. He had been suffering from "asthma" for many years. Following a severe coughing spell twenty-four hours before admission, he felt a sharp pain in the right upper part of his abdomen. The pain had increased steadily until the time of his admission. There had been no vomiting.

He appeared acutely ill and in pain with a temperature of 101°F. and a pulse rate of 80. The blood pressure was 142 systolic and 90 diastolic. Sibilant and sonorous râles were present in both lungs. In the right upper quadrant just below the costal margin and near the midline there was a firm tender mass 8 cm. in diameter. It was apparently fixed to the underlying tissues. The preoperative diagnosis was incarcerated ventral hernia, although hemorrhage into the right rectus muscle was suspected.

Operation was performed under local anesthesia by Dr. Myron A. Sallick who found a hemorrhage into the right rectus abdominis muscle just below the costal attachment. The muscle fibers adjacent to the hematoma were very friable. No active bleeding points were present. Exploration of the peritoneal cavity was negative. The wound was closed without drainage. The postoperative course was uneventful except for a mild staphylococcic infection of the wound.

COMMENT

The first case closely simulated acute appendicitis, and it was the most difficult diagnostic problem of the three reported cases. Neither mass nor ecchymosis was present. Additional confusion occurred because of rebound tenderness. The only suggestive sign of intramuscular hemorrhage was the limitation of spasm to the right rectus abdominis muscle. The second case was diagnosed as an intraperitoneal cyst because of the presence of a mass in the left, lower quadrant of the abdomen. The significant signs of an ecchymosis and a mass were present, but the correct diagnosis was not made because the possibility of a spontaneous hemorrhage into the rectus abdominis muscle had not been considered. In the third case the hematoma formed a fixed mass in the right upper quadrant which led to the incorrect diagnosis of incarcerated ventral hernia. All patients were over sixty years old.

SUMMARY

Spontaneous hemorrhage into the rectus abdominis muscle is discussed and three case histories are presented. In patients past middle life and in younger individuals with an acute febrile disease who present a clinical picture of varying degree characterized by abdominal pain, localized tenderness over the rectus muscle, a palpable mass and ecchymosis of the abdominal skin, hematoma of the rectus abdominis muscle is the preferable diagnosis. Operative therapy is usually indicated to control bleeding and to prevent a progressive hematoma with possible secondary infection.

REFERENCES

1. ASHKAR, P. A. Spontaneous rupture of right rectus muscle in pregnancy. Lancet, 2: 934–935, 1939.
2. CULLEN, T. S. and BRODEL, M. Lesions of the rectus abdominis muscle simulating an acute intra-abdominal condition. Bull. Johns Hopkins Hosp., 61: 295–348, 1937.
3. PAYNE, R. L. Spontaneous rupture of the superior and inferior epigastric arteries within the rectus abdominis sheath. Ann. Surg., 108: 757–768, 1938.
4. SNYDER, W. H., JR. Spontaneous hematoma of the abdominal wall following respiratory infection. Calif. & West. Med., 50: 25–28, 1939.
5. TROPHINOFF, A. M. Quoted by Payne.
6. VIRCHOW, R. Ueber Entzundung und Ruptur des M. rectus abdominis. Verbandl. d. phys.-med. Gesellsch., 7: 213, 1857.

IMPLANT SKIN GRAFTING*

CASE REPORT

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ON December 19, 1940, a boy of nineteen years was admitted to the Surgical Service of the Long Beach Hospital. He stated that five days before after siphoning a gas tank, he struck a match and his trousers caught on fire. He was treated at home by his family physician for third degree burns of the left leg for five days, but because the burn failed to respond to treatment, hospitalization was advised. The patient also stated that since he was a child he had had heart trouble and that only about two years before he had been confined to bed because of a heart attack.

Physical examination revealed that the heart was enlarged and at all valve areas there was systolic and diastolic murmurs characteristic of an old rheumatic heart disease. There was a third degree burn of the lower left extremity. This burn extended from the upper one-third of the thigh to just below the ankle joint. There was a thick crust over the leg, which was assumed to be tannic acid spray. At the upper one-third of the thigh directly above the burn on the external lateral surface there was a large indurated area. There was much necrotic tissue. On admission diagnosis was third degree burn of the entire left leg; rheumatic heart disease.

From the time of admission until January 14, 1941, local treatment was instituted to clear up the infection in the leg. All this time the patient had been running a toxic temperature. Many intravenous injections of 5 per cent glucose and saline were given. Vitamins and liver extract were given and his diet was a high caloric one.

From January 14, 1941, to February 14, 1941, three skin grafting operations were performed but they were not successful. He seemed allergic to the grafts. On April 9, 1941, the case was turned over to me for consideration and implant skin grafting on a massive scale was decided upon.

At operation on April 11, the left leg from thigh to ankle was covered with hot saline gauze dressings for two days. At this time the patient was considered a very poor risk on account of his cardiac and toxic condition. He had lost considerable weight.

Under cyclopropane anesthesia the left leg, on the anterior surface, was cleansed of its crust from the thigh to the ankle. Considerable bleeding occurred. From the right anterior thigh, a Thiersch graft 5 by 2 inches was removed with a razor. This graft was placed in a pan of sterile normal saline, then transferred to a sterile bass wood splint 4 by 10 inches which had been moistened with normal saline. With a sharp razor this large graft was cut into pieces one-quarter an inch square and left on the splint.

One of these small pieces was removed from the splint, placed with its freshly cut surface on the granulation tissue and tucked into the granulation tissue as you would tuck a letter into an envelope. Two large needles were used. They were reversed with points in artery clamps. The eye ends were employed to tuck the small graft in place, leaving just a small point protruding; the one needle kept the graft in place upon withdrawal of the other needle.

The grafts were tried at all depths and all positions; one hundred fifty grafts were placed at this operation on the anterior surface from thigh to ankle, and fully 90 per cent of the implants grew. Operating time lasted one hour. The grafts were covered with parawax gauze. Moist saline compresses were applied over the wax gauze and were changed several times a day.

For about one week no growth was visible and then many white skin islands began to appear from thigh to ankle. In the picture taken posteriorly it can be seen that the grafts are beginning to push their way up through the granulation tissue and to spread joining with the adjacent grafts. All stages are represented in this picture. (Fig. 1.)

On the anterior picture of the leg the junction of the new fibroplastic implants to the existing skin can be seen. There is a smooth

difference in the manner, time or the extent of growth as compared with the first method of implantation.

FIG. 1. Posterior view six months after initial grafting.

line of junction with no contracture and no raised edge. Only a faint white line at this site can be noticed. (Fig. 2.)

Considerable hemorrhage occurred at the sites of the communicating veins when disturbed by implanting grafts, but fibroblastic

The picture of the posterior surface of the leg was taken on October 8, 1941, and one month afterward all areas were healed and patient was up on crutches. Physiotherapy should now be instituted to restore the leg to normal function.
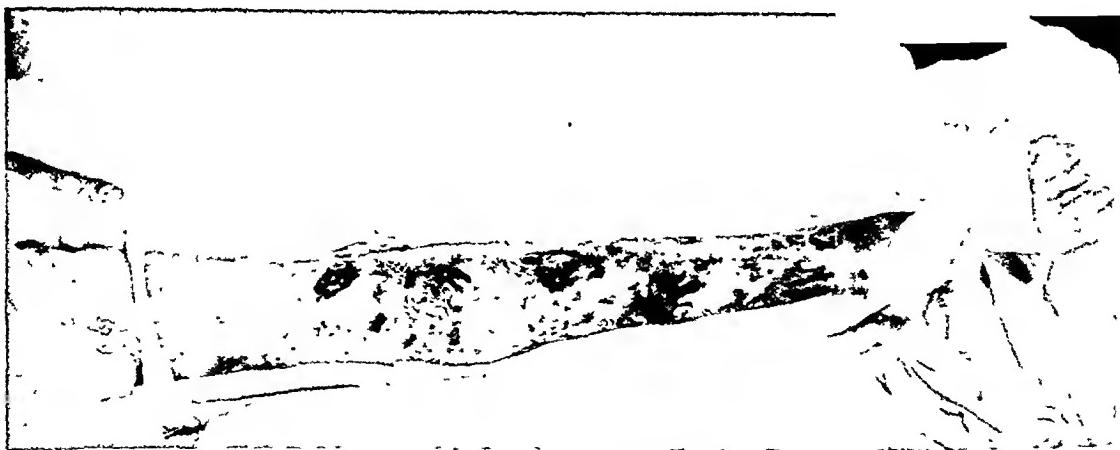
FIG. 2. Anterior view six months after initial grafting.

tissue gradually grew around the elevations, depressed and finally completely epithelialized them. There was no attempt at this operation to plant the skin grafts in a symmetrical manner. They were implanted in areas that would give us the least possible hemorrhage. Later on the grafts were implanted in the lines of squares but it did not seem to me that there was any

There were six implant operations from April 11 to September 22, 1941. There was a total of 650 implant grafts used. Twelve transfusions of 500 cc. each of citrated blood were given from January 6 to September 18, 1941. There were sixteen complete blood counts which showed a rather moderate leucocytosis. Many urinalyses were done. Blood cultures

were negative for twenty-four hours and for one week. Repeated cultures from the left leg showed a Gram-negative cocci resembling staphylococcus, also short chain nonhemolytic streptococci.

CONCLUSIONS

I believe that by using this technic grafts can be implanted earlier. This type of massive implant is particularly valuable in burns with large denuded areas because the burned areas will be epithelialized more quickly and the hospital stay shortened. One important factor to be observed in these operations is that they should be done in subdued light to avoid the heat killing of the grafts. There is one question yet to be answered: Will the pigmented layer of the skin grow under the fibroblastic implant and in time match the normal skin?

This method would be of inestimable value in the cosmetic treatment of facial burns with much loss of tissue. The earlier the implant the less contracture at the line of demarcation.

This is only a preliminary case report. As more cases are dealt with and we acquire more experience with this method, I believe that operative procedures and hospital stay can be markedly shortened, thus rehabilitating patients more quickly than with other methods.

This technic would be quite valuable in case of war, especially in the bombing of the civilian population in which hundreds of cases of major burns would occur.

The method and technic of implant grafting is quite simple, the after-care is not complicated and the results are fairly good. There is very little fibroblastic contracture in the implants at the present time. It would seem that the co-efficients of expansion and contraction of the fibroblastic layer and the inflammatory tissue are the same, therefore, there is no contracture at the line of junction with the existing skin. The edge of the existing skin was not freshened at the line of junction; the fibroblastic implants just merged with hardly a line of demarcation and there was no raised edge and no contracture.

REFERENCES

1. MARCKS. Implantation grafts. *Am. J. Surg.*, 51: 361, 1941.
2. POLLACK, A. G. Case of skin grafting and skin implantation. *Tr. Clin. Soc., London*, 4: 37, 1871.
3. BRAUN, WILHELM. Zur Technikder Hautpropfung. *Centralbl. f. Chir.*, 52: 1555, 1920. Über Haut profungen. As quoted by Wangensteen. *Klin. Wchnschr.*, 14: 335, 1921.
4. WANGENSTEEN, O. H. The implantation method of skin grafting. *Surg., Gynec. & Obst.*, 50: 634, 1930.
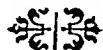
MIGRATING FOREIGN BODY

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CASE REPORT

MR. H. P. G., age fifty years, entered Newman Memorial Hospital following an automobile accident on April 12, brain with accompanying shock. The fracture of the leg was reduced and five days later the fractured patella was repaired surgically. At the time of admittance there was a laceration one inch in length in the midscapular line at the
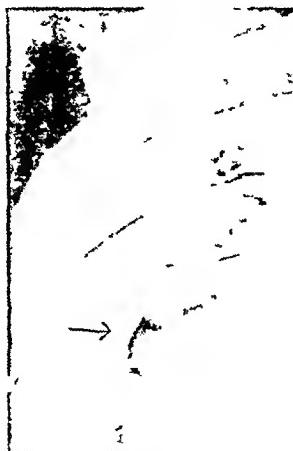
FIG. 1. Roentgenogram showing glass fragment.

FIG. 2. Lateral roentgenogram showing end-on view of fragment.
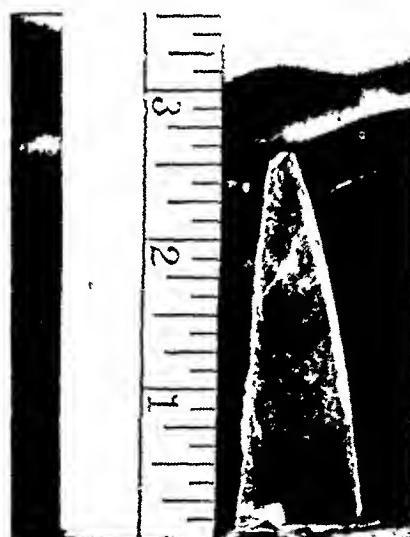
FIG. 3. Photograph of fragment after removal from anterior chest wall.

level of the tenth dorsal vertebra. No foreign body could be felt with a probe. There were no other lacerations of the chest wall.

The patient complained of pain in the left chest posteriorly and a few days after the patellar operation a roentgenogram was made

1939. He received a fracture of the upper third of the left fibula and tibia and of the right patella. He was suffering from concussion of the

of the chest. This revealed a triangular shadow at the level of the ninth dorsal vertebra. (Fig. 1.) The lateral view gave an end-on shadow of the foreign body. (Fig. 2.) Diagnosis was made of a foreign body, probably glass and possibly intrapleural. As the patient was a frail individual it was thought best not to subject him to operation at once, especially as the pain was lessening and there was no general reaction.

He was sent to his home to be under the care of the family physician. He was told to return if he had any trouble. This he did not do until nine months later. He then returned with a swollen inflamed area in the midclavicular line above the left nipple. This was opened under a local anesthetic. There was no pus but the blade of the scalpel came in contact with a hard, unyielding mass which gave off a metallic click. The object was grasped with a pair of forceps but could not be dislodged. The incision was

enlarged and disclosed the end of a fragment of glass protruding between the third and fourth interspace of the ribs. The fragment was rotated which made its removal possible. The fragment measured two and five-eighth inches in length, one inch in diameter at its base and was one-fourth inch thick. (Fig. 3.)

It is evident that the fragment migrated from the posterior position up through the pleural cavity to an anterior position and worked its way through the third interspace. The patient states that he had an occasional pain, not severe, and that he noticed after weeks went by that the pain moved higher up toward the left nipple. His convalescence was uneventful. It is regrettable that a film was not made just before removal of the glass.
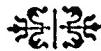
MASSIVE FATAL RECTAL HEMORRHAGE FROM CAPILLARY OOZING*

CASE REPORT

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IT is a well recognized fact that there is a wide variation in the responses of different patients to similar painful stimuli. Frequently we are annoyed by the loud complaints of hypersensitive individuals who grossly exaggerate the suffering which they experience from minor ills and injuries. On the other extreme is the patient who has little complaint to make even though he is beset by a serious illness or accident. Apparently some of these patients bear their pain with Spartan bravery. In other patients I am convinced that the mechanism of pain appreciation is not normally responsive and these individuals actually do not experience pain in the usual manner. The problem of diagnosis is much more difficult in this inarticulate group. It does not make much difference whether the lack of response to painful stimuli is due to a determined stoicism or to an aberration from the normal process of pain appreciation.

By way of illustration I have in mind one particular patient, Mr. X, whose death may have been brought about because of the fact that he did not experience pain in the usual manner, or if he did experience it, he did not betray it in a convincing manner to his examiner. It is the story of a case of acute appendicitis which passed unrecognized by one of the most competent and conscientious general practitioners of my acquaintance. It ill becomes any of us to lift a critical eyebrow at the mention of an unrecognized acute appendicitis. There are few physicians of any considerable experience who have not had the same tragic experience, not once, but several times. Those of us who watched this

particular patient through his many weeks of hospitalization marvelled at the fact that he complained of practically no pain in spite of several surgical manipulations and many unusual complications.

Mr. X was a well developed man, fifty years of age, who enjoyed good health practically all of his life with the exception of one attack of typhoid fever in 1905. His right hip was fractured in a train accident several years ago. He never had any previous surgical experience. He enjoyed his usual good health and continued actively at his work up until seventeen days before his admission to the hospital. On the day his illness began he went to work as usual but about noon he began to experience a mild, hunger-like pain in the lower abdomen. The discomfort began in the middle of the abdomen but moved over toward the right lower quadrant later in the day. It never became sharply localized at any point. He ate his noon lunch in spite of the fact that he felt nauseated. In the course of the afternoon he felt weak and tired. About 4 p.m. he went home and went to bed. Later in the evening he vomited the food which he had taken. That night he felt feverish. Later he perspired and had a shaking chill. There was no diarrhea, hematuria or dysuria. The patient remained about the same the next day. He vomited a second time in the course of that day. During the subsequent interval, prior to his admission to the hospital, he was never acutely ill. On the other hand, he did not feel strong enough to go back to work. He had a fever of one or two degrees each day, felt weak, and had no appetite. On close questioning, he admitted a mild constant discomfort in the lower right quadrant. Sometimes mild tenderness could be elicited on palpation but at other times deep pressure seemed to cause him no particular distress. His physician was at a loss to explain

his continued fever. He had in mind the possibility of appendiceal abscess, but the picture was not convincing. It resembled a typhoid state. Faced with a fever of undetermined origin, his physician sent him to the hospital for investigation.

When we first saw the patient and heard the story of his illness, the possibility of appendiceal abscess was foremost in our minds. The patient rather grudgingly admitted vague discomfort in the right lower quadrant. Otherwise, he had no complaints and indeed seemed rather vigorous. We could find no mass. At times there was a little tenderness on palpation but it was not constant. Rebound tenderness was so mild as to be unconvincing. There was no appreciable muscular rigidity. Thinking of the possibility of a pelvic abscess, a rectal examination was done but that yielded absolutely no positive findings. The urinalysis was negative as well as the Widal and the agglutination tests for undulant fever. The routine blood count suggested a mild pyogenic infection and a moderately severe secondary anemia. It was as follows: red blood count, 3,970,000; white blood count, 11,600; hemoglobin, 65 per cent; polymorphonuclears, 82 per cent; lymphocytes, 18 per cent.

In view of the pronounced secondary anemia and the rather vague symptoms in the right lower quadrant we asked to have the colon visualized by x-ray having in mind the possibility of a neoplasm involving the cecum. At the same time we asked for an x-ray study of the chest. The report by Dr. C. H. Clovis from the X-ray Department was as follows:

"Stereoscopic radiographic study of the chest shows multiple well healed tubercles throughout both lungs having the appearance of an old healed miliary T. B. There is no evidence of new lesions in the lungs. The heart is moderately enlarged to the left.

"Study of the colon by barium enema reveals a filling defect in the neighborhood of the cecum involving the gut for about three or four inches. The appearance is that of an external pressure, possible newgrowth or appendiceal abscess.

"X-ray diagnoses:

1. Old well healed T. B. of the lungs.

2. Heart slightly enlarged to the left.

3. Defective filling of the cecum and first portion of the ascending colon.

4. Probable walled-off abscess, possible newgrowth."

At this point in our study of the case there seemed to be no reason for further delay in requesting surgical assistance. Dr. R. B. Bailey was called in consultation and made the following observations: "The history is very suggestive of appendicitis, the barium enema shows a definite lesion about the cecum. The patient is very tender over the cecum. Probable diagnoses: one, walled-off appendiceal abscess; two, inflammatory typhilitis (similar to the pathology of terminal ileitis); three, carcinoma of cecum with perforation. Advice—exploration."

The abdomen was opened by Dr. Bailey on the twenty-second day of the patient's illness. He found a large appendiceal abscess in the right colic gutter. There was no attempt to explore the remaining viscera after the abscess was encountered. The abscess was drained and a large rubber tube, together with two iodoform packs were inserted. The packs were necessitated by the presence of oozing from the abscessed wall. No part of the appendix was identified at the time of the operation.

The patient's immediate postoperative course was quite stormy. On the second and third postoperative days the temperature went above 104°F. At this time blood transfusions, sulfathiazole and Wangensteen drainage were instituted. During the period of hospitalization the patient was given a transfusion about every fifth day. Sulfathiazole was administered for approximately one week at the rate of 15 gr. every four hours. The patient seemed to have recovered quite nicely from his operation after ten or twelve days but he continued to have a daily temperature elevation to 99.5 or 100°F. At the end of two weeks the drain was removed and for a few days the patient seemed to be in such good health that we were sure he would recover. For two whole days the temperature remained normal.

We were disappointed and chagrined when the fever returned and the patient again appeared ill about the twentieth day after operation. He was subjected to repeated physical examinations by different men on the staff. Each examination yielded negative results. The patient never complained of pain or tenderness. There was no palpable mass at any time. Occasionally he exhibited abdominal distention but most of the time the abdominal walls were flaccid. Repeated blood cultures were negative. Several examinations of the chest were made with no pathological findings.

In spite of transfusions, his secondary anemia persisted and his hemoglobin touched 55 per cent. Sulfathiazole was administered in the dosage mentioned above for another week. It had little or no effect upon the temperature. Several stool examinations were negative for occult blood. Urinalyses cast no light upon the problem. In the sixth week after operation we noticed for the first time that the patient was jaundiced. The observation was confirmed by finding the icteric index to be thirty-five. Throughout the entire period the patient complained of no pain or tenderness. As a matter of fact, he became rather listless and drowsy. We asked for a blood urea determination and found it to be normal.

One night a few days after the jaundice appeared the patient complained of discomfort in the right flank. This was perhaps his one and only real complaint at any time. We could make out nothing unusual on examination but the next day the incision opened up unexpectedly and a very large amount of pus and bile drained out. Because of the great amount of bile drainage, he was given vitamin K with bile salts. In addition, sodium chloride was given in an attempt to combat the low blood chloride content which would inevitably result from a persistent bile drainage. The blood chlorides were estimated at 225 mg. per 100 cc. at the beginning of this treatment. It is interesting to note that they returned to normal within three days after the institution of treatment with sodium chloride. We were interested to note that this result was accomplished solely by the oral administration of sodium chloride.

In the days immediately following the sudden drainage of this large amount of bile and pus from the incision the patient began to manifest considerable clinical improvement. We were dismayed by the appearance of this quantity of bile. We considered the possibility of a liver abscess which had ruptured and drained in this dramatic fashion. We also considered the possibility that the patient had had an empyema of the gallbladder and that the gallbladder instead of the appendix might have been the offending organ. While we waited and watched for new developments, the patient remained quite comfortable though very weak. His hemoglobin remained low (60 per cent). The icteric index remained at thirty. He continued to have daily temperature elevations to 101°F. The fact that the patient did not get worse, even though actual improvement was not noticeable, encouraged a more hopeful attitude. He continued to feel fairly well for ten or twelve days and then suddenly without the slightest warning he had a massive hemorrhage per rectum. According to the nurse's notes, there were five bed pans half full of blood clots. He was given three transfusions on the day of the hemorrhage. Each transfusion consisted of 700 cc. of whole blood and on the following day he was given a similar transfusion. In spite of this energetic treatment the hemoglobin was registered at 59 per cent after the fourth transfusion. Other smaller hemorrhages followed in the next few days. These hemorrhages, which occurred during the last week of the patient's life, were probably not due to a deficiency of vitamin K. The prothrombin clotting time was found to be normal when estimated by Dr. M. A. Shilling who supervised the clinical care of this patient during his entire postoperative course. The patient's shock was fairly well controlled by multiple transfusions, but the bleeding per rectum continued intermittently and the patient succumbed on the fourth day after the massive hemorrhage.

Why did this patient have hemorrhages from the rectum? What pathological entity could account for (1) a walled off retrocecal abscess? (2) an enormous amount of bile drainage through the abscessed cavity? and (3) fatal hemorrhages from the rectum? We discussed this problem at great length. Not one of us was able to offer a satisfactory answer before we received the following report from the pathologist, Dr. H. G. Little:

"The body is that of a well developed white male adult. There is a slight icteric color in the skin. There is an incision in the right abdominal wall in which there is a drain that extends into the abdominal cavity in the region of the cecum.

"On opening the peritoneal cavity there is found a rather thick purulent exudate in the pelvic cavity and scattered fibrinous exudate over the serosal surfaces of the intestines. The purulent exudate originates around the cecum. Here the cecum is firmly adherent to the parietal peritoneum and further examination discloses that most of the appendix has entirely disappeared in the mass of adhesions

and purulent exudate. Extending upward retroperitoneally from the base of the cecum, the purulent exudate has separated the peritoneum from the lateral abdominal wall. The exudate continues upward to the region of the portal vein. Following the right branch of the portal vein the exudate is traced to a large abscess involving almost the entire right lobe of the liver. The liver tissue is necrotic and considerable purulent exudate is present. The walls of the abscess are not well defined and the border extends slightly into the left lobe of the liver.

"The portal vein is not thrombosed. There are soft, enlarged lymph-nodes around the common bile duct, also the retroperitoneal and the mesenteric lymph-nodes are enlarged.

"At the brim of the pelvis there is a nodular mass in the mesentery attachment to the colon. On section this mass, grossly, consists of fat and fibrous connective tissue. The colon adherent to this mass shows no ulceration of the mucosa.

"The spleen is larger than normal. It is soft and boggy.

The gastrointestinal tract shows no tumors.

"The kidneys are normal in size and on section the markings are distinct and, grossly, no pathological changes are noted.

"Examination of the lungs showed no pneumonia. There is moderate congestion of the lower lobes of the lungs.

"The heart is normal in size and, on section, the myocardium is firm, the valves are normal.

"Culture from the pus in the liver showed some streptococci and B. pyocyaneus.

"In summary, this case was apparently a primary appendiceal abscess with the infection extending upward and into the liver to form the liver abscess.

"*Microscopic Examination.* Examination of the mesenteric nodule shows it to be composed of fat in which there is diffuse chronic inflammation. The lymphocytic and mononuclear infiltration extends into the musculature of the colon. The vessels in the submucosa and the capillaries of the mucosa are congested. Since this area in the colon was the only portion that

showed any lesions, it is possible that there was bleeding from the congested capillaries in the mucosa. The nodule was of sufficient density to cause considerable localized pressure.

"*Anatomical Diagnoses.* 1. Primary periappendiceal abscess with extension through parietal peritoneum. 2. Abscess of right lobe of liver. 3. Fibrinopurulent peritonitis with effusion. 4. Localized congestion of the capillaries of the colon with hemorrhage."

SUMMARY

We have related the unfortunate history of an unrecognized case of gangrenous appendicitis in an individual whose appreciation of pain was remarkably dull. The pus from the appendiceal abscess perforated the parietal peritoneum and travelled upward to the liver. Extending along the right branch of the portal vein the infection produced an enormous liver abscess which later ruptured and drained through the appendiceal incision. Further extension of the infection proceeded by the retroperitoneal route toward the pelvic brim. The mesentery was involved and in one particular area an inflammatory tumor developed. This tumor was adjacent and adherent to the sigmoid. The wall of the sigmoid was edematous and congested at the area of contact. No open lesion of the sigmoid or in fact any portion of the intestinal tract could be demonstrated at autopsy and yet this patient expired as a result of a massive rectal hemorrhage. The remarkable feature of the case is the fact that such a large quantity of blood reached the lumen of the bowel through an intact but congested mucosa. Capillary oozing of this character is frequently noted in the stomach resulting in the so-called coffee-ground vomitus. In our experience such bleeding on an extensive scale is rarely seen in the lower end of the intestinal tract.
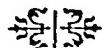
REMOVAL OF INTRAPLEURAL FOREIGN BODY UNDER THORACOSCOPIC GUIDANCE*

CASE REPORT

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CASE REPORT

J. B., a white male of twenty-six, was referred to Jefferson Hospital on May 12, 1941, from a Pennsylvania sanatorium.

FIG. 1. Preoperative x-ray of chest showing needle in situ.

He had been receiving therapeutic pneumothorax for pulmonary tuberculosis since November, 1939. On May 6, 1941, while receiving a pneumothorax refill the needle broke off at the hub and lodged in the chest wall. An incision was made and removal of the needle attempted. During the course of the procedure the needle was forced into the pleural cavity and lodged in the posterior portion of the right costophrenic sinus. A small amount of fluid developed.

On May 14, 1941, under local anesthesia a thoracoscope was inserted into the pleural cavity in the eighth interspace posteriorly. The needle was visualized partially imbedded in the chest wall of the costophrenic sinus. The needle was partially covered with fibrin and there was some inflammatory reaction around it. A second trocar opening was made anteriorly just above the diaphragm and a Jackson type of bronchoscopic grasping forceps was introduced. Under
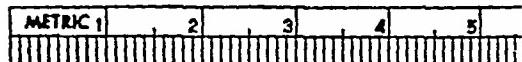
FIG. 2. Photograph of needle after removal.

thoracoscopic guidance the point of the needle was seized and it was withdrawn through the anterior trocar opening. The openings were closed with interrupted black silk sutures. The patient's course was uneventful and he was sent back to his sanatorium on May 17, 1941.

COMMENT

Since closed intrapleural removal of foreign bodies is a relatively rare procedure we believe this case should be on record. There are several lessons taught in this instance which should be stressed. It is highly important that pneumothorax needles be of the finest grade of rustless steel and that needles be carefully examined and tested before using. The needle we removed was of a poor grade of ordinary steel needle and was rusted through at the hub. Secondly, embedded foreign bodies in the chest wall as elsewhere, had better be left alone until expert surgical attention and proper fluoroscopic guidance are available. Lastly, this case illustrates that where the facilities are available, intrapleural foreign bodies can be removed without subjecting the patient to the hazards of a major thoracotomy.

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ALLERGIC REACTION FOLLOWING BLOOD TRANSFUSION

APPARENT DESENSITIZATION OF RECIPIENT

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NO method of blood transfusion has ever been devised that is not followed by occasional reactions. Some of the reactions can be ascribed to a certain cause; more often the cause remains obscure. Reactions are manifested by fever, malaise, nausea, vomiting, chilly sensations or actual rigor, muscular pains, dyspnea, cyanosis, pruritis, urticaria, headaches, icterus, suppression of urine, hemoglobinuria and casts. The increase in temperature may vary from 2 to 10°F.

Ramirez[1] described passive transmission of sensitivity to horse dander by transfusion. The recipient was permanently sensitized.

Carrington and Lee[2] reported a transfusion reaction that followed the administration of 50 cc. of compatible blood. Dyspnea, laryngeal stridor, cyanosis and pulmonary edema developed, and the patient became comatose and died. There was no hematuria or hemoglobinuria.

Bottner[3] cited several instances of reaction to transfusion which, because of their nature, the presence of eosinophilia and the fact that the transfusion occurred three to six weeks after the first, indicated that the reactions were allergic. Gray[4] reported a case in which liver eaten by the donor produced urticaria in a sensitive recipient. Holder and Diefenbach[5] and Tedstrom[6] reported the passive transmission by transfusion of allergy to strawberries. Littlefield[7] and Hancock[8] reported passive transmission by transfusion of allergy to eggs.

Kordenat and Smithies[9] state that so-called "anaphylactic reactions" are really due to protein shock which may occur in one of two ways: (1) the donor's blood may increase the protective or cleavage action of damaged tissue which produces the reaction; (2) because of poor proteopexic ability of the liver, partly altered proteins leak through, resulting in parenteral cleavage and nonspecific protein shock (Widal crisis).

Three cases are here reported in which various donors were used for transfusion and following each transfusion an allergic reaction occurred. An apparent desensitization is also described.

CASE REPORTS

Case 1. A man, aged sixty-six, had been suffering from a perinephric abscess of two months' duration. Hemolytic staphylococcus aureus had been cultured from the pus. He had had a continuous spiking fever for two months and was considered seriously ill. When first seen he was dehydrated and the hemoglobin was only 54 per cent (Sahli) and the red blood cell count was 2,100,000. It was decided that he should have repeated transfusions until the hemoglobin was above 80 per cent. The patient belonged to Group III Moss. All transfusions were given slowly by the indirect method using citrated blood. The patient was retyped before each transfusion and each time still belonged to Group III Moss.

Transfusion, August 9, 1938. The donor belonged to Group IV Moss (universal donor). Six hundred cc. of whole citrated blood was given. Following the transfusion urticaria developed. On questioning the donor admitted that he had never eaten tomatoes because they made him ill. The recipient had had tomatoes for dinner. The reaction was considered to be allergic.

Transfusion, August 10, 1938. A fasting donor, belonging to Group IV Moss, was used. Approximately 100 cc. of whole citrated blood had been given when urticaria developed. The transfusion was immediately stopped and

adrenalin was administered. The patient complained of headache, his temperature rose to 104°F., and he became irrational.

Transfusion, August 12, 1938. The scheduled donor did not arrive and the mental state of the patient was such that he was not acquainted with the fact. The blood remaining from the transfusion of August 10, 1938, was taken from the ice-box, and 10 cc. given, with adrenalin at hand ready for use. This transfusion was given with the thought that it could be discontinued immediately if urticaria developed, and the patient would thus be spared the knowledge that his friend, the donor, had deserted him. However, urticaria did not develop, and the transfusion was continued until 400 cc. had been given with no reaction whatever. This was the same blood that two days previously had produced such a severe reaction.

Transfusion, August 15, 1938. The donor belonged to Group IV Moss. After 500 cc. had been given, urticaria developed and adrenalin was administered. The transfusion was continued until 700 cc. had been given. The urticaria was present for three hours after the completion of the transfusion.

Transfusion, August 16, 1938. It was decided to discontinue the use of the universal donor and for this transfusion a donor of Group III Moss was used. The cross-match was perfect. Fifty cc. of whole blood was given. Adrenalin was administered three times during transfusion because of urticaria.

Transfusion, August 18, 1938. A donor of Group III Moss was used. The cross-match was perfect and 150 cc. of citrated whole blood was given. A severe reaction followed, the temperature reached 104.5°F., the patient became irrational, and adrenalin was given. The remaining blood was placed in the ice box.

Transfusion, August 19, 1938. Up to this time, the only transfusion that had not been followed by urticaria was the one in which blood that had been kept in the icebox was used. For this reason the remainder of the blood that had produced a severe reaction on August 18th was taken from the icebox and 50 cc. of this blood was given with no reaction whatsoever.

Transfusion, August 20, 1938. The donor belonged to Group IV Moss. Urticaria developed after 600 cc. of citrated whole blood had been given.

Following the last transfusion the hemoglobin was 104 per cent, the red blood cell count was 5,000,000 and the patient was much better symptomatically. His fever began to disappear and he gained strength. The blood smear showed an eosinophilia at all times The urine showed from 0 to 15 mg. of albumin. At no time was there hemoglobinuria.

CASE II. A woman, aged sixty-five, recovering from a resection of the bowel for carcinoma of the colon, was suffering from mild shock and a transfusion was ordered. The patient was Group II Moss with no allergic history.

Transfusion, September 3, 1940. The donor belonged to Group II Moss. Five hundred cc. of whole citrated blood was drawn. After 50 cc. of blood had been given, urticaria developed and the patient suffered a chill. The transfusion was stopped. On the following morning the remainder of the blood, 450 cc. was given without reaction.

Transfusion, September 16, 1940. The donor belonged to Group II Moss. Five hundred cubic centimeter of blood was drawn. Urticaria developed after 100 cc. had been given. The transfusion was stopped and the remainder, 400 cc. was given the following morning without reaction.

CASE III. A man, aged twenty-nine, recovering from a crushing injury of the abdomen, was suffering from severe shock and a transfusion was ordered. The patient was Group II Moss, and gave no history of allergy.

Transfusion, December 11, 1940. The donor belonged to Group II Moss and had no history of allergy. After 100 cc. of whole citrated blood had been given urticaria developed. The transfusion was stopped, and the remainder of the blood, 400 cc., was given the following day without reaction.

Polayes and Lederer[10] have listed the causes of transfusion reactions. Their outline has been followed in an effort to find the reason for the reactions in the cases reported here.

1. Incompatibility between donor's and recipient's blood (3 causes).

(a) Errors in grouping the blood due to the following causes in order of importance:

1. *Poor technic:* The blood was typed by the regular, trained technician

and checked by myself. There were no similar reactions occurring in the hospital.

2. *Use of low titered or contaminated test serum:* The serum used was collected from relatively high titered donors and was definitely not contaminated.

3. *Weak agglutinins or agglutinogens in the recipient's blood.* Agglutination occurred quickly. The patients belonged to correct Groups.

4. Pseudo-agglutination: The patients naturally would have a rapid sedimentation rate, but the grouping was done microscopically.

5. *Auto-agglutination:* This was definitely not present.

6. *Anomalous or atypical agglutination:* The agglutination was done with warmed serum.

7. *Contamination of recipient's blood by bacteria:* The blood may have been contaminated, but, since it was fresh, significant growth could not have occurred.

(b) *Indiscriminate use of universal donor:* Reactions occurred with donors of the same group as well as with a universal donor. The reactions were allergic in type. A universal donor was used in one of the two transfusions in Case 1 that was not followed by a reaction.

(c) *Immune iso-antibodies and hemolysins:* The recipient had never had a transfusion prior to this illness.

ii. *The use of unclean apparatus:* The apparatus was clean; no new rubber tubing was used.

iii. *The use of citrate solutions:* A highly controversial question. The blood that was given without a reaction was citrated. Skin tests with citrate solution produced no reaction.

iv. *Incipient coagulative changes in transfused blood:* The reactions were not of this type.

v. *Allergic phenomena in recipient.* None were present, but were present in the first donor of Case 1. The reactions were allergic in character.

vi. *Systemic diseases in the recipient.* Reactions based on the presence of sys-temic diseases occur in patients with renal disease or renal disease develops as a result of the reactions. Pyelograms, renal and urine studies of this patient showed no renal disease, and renal disease never developed nor did the patient ever pass abnormal urine. Because of the character of the reactions they were considered to be allergic.

COMMENT

Six donors were used for eight transfusions to the same recipient in Case 1. When the blood was first used, a reaction followed in each instance. In two instances in which the reactions were severe the remaining blood was placed in the icebox for forty-eight and twenty-four hours, respectively. When the blood was used a second time, no reaction occurred. This represents either a desensitization of the recipient or a "detoxification" of the blood by standing in the icebox. These two possibilities were investigated. Blood was drawn from a donor belonging to Group iii, citrated, and placed in the icebox. After forty-eight hours another sample of blood was obtained from the same donor and citrated. Three intradermal injections of 0.1 cc. each of forty-eight-hour old citrated blood that had been standing in the icebox, of fresh citrated blood and of citrate solution were made on the flexor surface of the fore arm of the patient described in Case 1. There was no reaction to the citrate solution. A wheal of pseudopods quickly formed at the site of the injections of both the old and fresh blood. The wheals were 1 inch to 1.5 inches in diameter. It was concluded that the blood was not changed by standing in the icebox and that probably a desensitization of the recipient had occurred following the first transfusion. This accounted for the absence of reaction when a donor was used a second time. Nine months after the transfusions had been given, the skin tests were repeated with the same results. As far as the recipient knows he has not been permanently sensitized to any food or other matter.

SUMMARY

1. Three cases are reported in which a supposed allergic reaction followed transfusion, when blood which had previously produced urticaria was used, no urticaria or allergic reactions developed. This probably represents a desensitization of the recipient by the first transfusion.

2. The causes of reactions to transfusions are reviewed.

3. Skin tests showed that the blood still produced urticaria after the blood had been stored twenty-four to forty-eight hours in the icebox. It was, therefore, concluded that storage of the blood in the icebox did not detoxify the blood.

4. When a blood transfusion is accompanied by an allergic reaction, it is always advisable to discontinue the transfusion and obtain blood from another fasting donor.

5. When, however, there are reactions following the use of every obtainable donor, it seems reasonably safe to give a very small transfusion, place the remaining blood in the icebox, then give the remainder of the blood in twenty-four hours after a desensitization of the recipient has occurred.

REFERENCES

1. RAMIREZ, M. A. Horse astha following blood transfusion. *J. A. M. A.*, 73: 984–986, 1919.
2. CARRINGTON, G. L. and LEE, W. E. Fatal anaphylaxis following blood transfusion. *Ann. Surg.*, 78: 1–5, 1923.
3. BOTTNER, A. Anaphylaxis in blood transfusions, *Deutsche med. Wchnschr.*, 50: 599–600, 1924.
4. GRAY, J. W. Therapeutic value of blood transfusions, *J. Med. Soc. New Jersey*, 25: 17–22, 1928.
5. HOLDER, H. G. and DIEFENBACH, W. E. Urticaria—its passive transmission by blood transfusion *Calif. & West. Med.*, 37: 387–388, 1932.
6. TEDSTROM, M. K. Active transmission of urticaria by blood transfusion. *J. Allergy*, 5: 303–305, 1934.
7. LITTLEFIELD, J. B. Reactions in blood transfusions. *Southwest. Med.*, 18: 52–57, 1934.
8. HANCOCK, J. D. Allergic reactions following transfusion, *South. Surg.*, 5: 373–374, 1936.
9. KORDENAT, R. A. and SMITHIES, F. Phenomena concerned with "reactions" following transfusion of blood. *J. A. M. A.*, 85: 1193–1200, 1925.
10. POLAYES, S. H. and LEDERER, M. Reactions to blood transfusions. *J. Lab. & Clin. Med.*, 17: 1029–1043, 1932.

LYMPHOSARCOMA OF THE INTESTINAL TRACT

REPORT OF A CASE IN WHICH THERE WAS AN APPARENT FIVE-YEAR CURE

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LYMPHOSARCOMA of the intestinal tract is not a rare disease. Benjamin and Christopher[1] have recently added to the literature the 380th case of lymphosacroma of the small intestine. Since this report, Chont[2] has reported three additional cases with reference to their radiosensitivity.

The most common site for this neoplasm, according to Geschickter[3] is the ileum, followed by stomach and cecum in that order. Usually the growth is localized, starting in the submucosa and assuming either central ulceration with dilatation of the involved bowel or polypoid growths extending into the lumen. Early extension to the mesenteric nodes is common and there are often adhesions to surrounding abdominal organs. Later there is a generalized hematogenous spread. Ullman and Abeshouse[4] in summarizing their series of 126 cases of lymphosarcoma of the small and large intestine, point out that the tumor has an obscure etiology, occurs most frequently in white males, may occur at any age in life but most often in the first, third and fourth decades, commonly metastasizes and is often associated with intussusception. They also add that there is no characteristic clinical syndrome, which accounts for the difficulty in differentiating this condition from other intra-abdominal diseases. In most cases the predominant symptoms are those of an acute or chronic intestinal obstruction.

In the treatment of lymphosarcoma of the intestinal tract radical surgery of the involved segment and its mesentery, followed by x-ray, appears to offer the best results. While this treatment has appeared to prolong life in many instances, the prognosis for permanent arrest or cure must still be regarded as pessimistic. In the series reported by Ullman and Abeshouse,[4] there were eighty-five cases in which the follow-up was definite; of these only ten patients were alive and well five years or more after operation with no signs of recurrence. Sugarbaker and Craver[5] in analyzing 196 histologically proved cases of lymphosarcoma, of which eleven rose in the intestinal tract, report fourteen apparent five-year cures; none of these cures was in the intestinal group. The average survival period in which the stomach or small intestine was involved was only 6.6 months. These authors conclude that probably the single most important factor determining success or failure lay in some inherent quality of the disease which as yet it is impossible to evaluate. They could not predict on the basis of histology which of two clinically similar cases was apt suddenly to become generalized and which would remain localized for a considerable period.

Between 1928 and 1940 there were eleven cases of lymphosarcoma of the intestinal tract in which the patients were operated upon at the New York Post-Graduate Hospital. Of these, seven were males and four were females. The average age was fifty, the average duration of symptoms was nineteen months. The majority of these patients suffered from symptoms suggestive of chronic partial intestinal obstruction and this was the most frequent preoperative diagnosis. The

tumor was present in the stomach in five cases, in the ileum in five and in the rectum in one. Careful follow-up was secured in only seven cases, of these only one patient lived longer than six months.

CASE REPORT

M. D., a white, married, elevated train motorman, aged fifty-five, entered New York Post-Graduate Hospital August 18, 1936, complaining of recurrent attacks of generalized, cramp-like, abdominal pain, accompanied by nausea and vomiting, during the preceding two and one-half years. He also suffered from progressively severe constipation necessitating daily catharsis. For the three weeks just before admission, he had vomited almost all food ingested and had lost twenty-one pounds in weight. There was no history of blood in the vomitus or stool.

Examination revealed a thin, dehydrated, cachectic individual. Visible active peristalsis was evident over the entire abdomen. No palpable masses were present. A hydrocele on the right side was noted. Fluids were given parenterally and operation performed the following day. At operation, intestinal obstruction was found due to a tumor of the upper ileum. The involved intestine, 10 cm. in length, was resected and a first-stage Mikulicz operation performed.

The postoperative course was uneventful and on the fifteenth day crushing clamps were applied. On the thirtieth day, reoperation was done for closure of a persistent sinus. At this operation, it appeared that a portion of the mesentery of the ileum was still involved. This mesentery and a 6 cm. section of intestine, including the anastomosis, was resected and an end-to-end anastomosis performed. The postoperative course was again uneventful and the patient was discharged on the twentieth postoperative day.

The pathological report disclosed a segment of ileum, 10 cm. in length, two-thirds of which was greatly dilated, thick-walled and contained an extensive, ulcerated fungating lesion. Tumor tissue was evident grossly through all the layers of the intestinal wall with numerous small nodules on the serosal surface. Microscopically, the basic pattern of the neoplasm was a fine connective tissue network upon which there were numerous layers of closely packed cells apparently arising in lymphoid tissue. The cells had round deep staining vesicular nuclei, with numerous mitotic division figures. Only chronic inflammatory changes were present in the mesentery. The diagnosis was malignant lymphoma of the ileum.

Following discharge from the hospital the patient returned to work. No x-ray therapy was given. He had to observe no dietary rules and has gained fifty pounds of weight. In July, 1940, he returned to the hospital for excision of his hydrocele.

When last seen on November 3, 1941, more than five years after the operation, the patient was in extremely good condition and free from all complaints. His belly wall was firm. He stated that he works every day and does not observe any dietary routine. At the time of his admission to the hospital he weighed 112 pounds and on this day he weighed 170 pounds.

SUMMARY

A case of lymphosarcoma of the small intestine is reported with an apparent five-year cure. Treatment consisted of radical surgical removal of the involved intestine and its mesentery.

BIBLIOGRAPHY

1. BENJAMIN, E. L. and CHRISTOPHER, FREDERICK. Primary lymphosarcoma of the small intestine. Report of a case. Am. J. Clin. Path., 10: 408, 1940.
2. CHONT, L. K. Sarcomas of the small intestine and reference to their radiosensitivity. Radiology, 36: 86, 1941.
3. GESCHICKTER, C. F. Tumors of the digestive tract. Am. J. Cancer, 25: 130, 1935.
4. ULLMAN, A. and ABESHOUSE, B. S. Lymphosarcomas of the small and large intestines. Ann. Surg., 95: 878, 1932.
5. SUGARBAKER, EVERETT D. and CRAVER, LLOYD F. Lymphosarcoma. J. A. M. A., 115: 17, 1940.

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THE EVOLUTION OF BLOOD TRANSFUSION*

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BLOOD has always been associated with life and strength. Among primitive man's earliest experiences is the observation that life flows out of the body with the streaming blood. We are told that even the apes stuff leaves and moss into bleeding wounds to staunch the flow and preserve life. How natural, therefore, to attempt to restore life and youth and strength by the administration of healthy blood. The use of blood as a therapeutic agent is thus as old as medicine itself. Blood of man and diverse animals in various forms and combinations is found in all early pharmacopias. The ancient Egyptian princes are reported to have used baths of blood for resuscitation and recuperation. During the Roman Empire, it was customary for the patrician spectators to rush into the arenas to quaff the freshly flowing blood from the severed jugulars of the dying gladiators. History and mythology record ever recurring endeavors to cure disease, insanity and old age by replenishing the store of vital blood.

The actual expedient of transfusing blood could not be expected, however, to have had serious consideration before the discovery of the circulation by Harvey in 1616. It must be remembered that prior to this date, the Galenic concept prevailed, that blood was generated in the liver and that it moved back and forth in the vessels until used up. While it is true that several Renaissance writers speculated upon the possibilities of transferring blood from one person to another, actual experimentation necessarily followed Harvey and knowledge of the circulation.

The first co-ordinated and scientific studies on infusion and transfusion were done in England, probably because of the direct stimulation of Harvey's lectures. The astronomer and architect, Christopher Wren, first injected drugs into the veins of dogs in 1656, by means of bladders fastened to quills. He described his experiments to his friends, Wilkins, Robert Boyle and others, and they pursued them further. In the following year, the first human infusion was done in London, into a convicted criminal.

The first successful transfusion of blood from one animal to another was performed in 1665 in Oxford, and later, in London, by Richard Lower, anatomist and physician, who did "this experiment, hitherto looked upon to be of almost unsurmountable difficulty" by uniting the artery of one dog with the vein of another by means of quills or silver tubes. Reports of these achievements spread to other countries, and in the following year, the first human transfusion with animal blood was done in Paris by Jean Baptiste Denis. Denis' early experiences include, besides a number of successful transfusions, a classical observation of increasing sensitization with repeated animal blood injections, which resulted in successively severe reactions and culminated in the first transfusion death. The patient, a lunatic, had twice been given

blood transfusions with temporary alleviation of his mania. Following the second transfusion, "his arm became hot, the

The rediscovery of blood transfusion in the nineteenth century was again the contribution of an Englishman, the London

FIG. 1. Earliest illustration of blood transfusion. Lamzweerde, 1672.

pulse rose, sweat burst out over his forehead, he complained of pain in the kidneys and was sick at the stomach. The next day the urine was very dark, in fact black." A third transfusion, undertaken at the request of the patient's wife, resulted in death. Denis' enemies hastened to make capital of this misfortune. They conspired with the widow to bring action against the transfusor, charging him with murder. A prolonged legal battle ensued in which Denis was eventually exonerated on the murder charge but further transfusions were prohibited. Similar bans were applied in other countries, and the first chapter in the history of blood transfusion was closed.

Except for an occasional sporadic attempt, the operation fell into complete desuetude for a period of almost 150 years. In this interim, however, some knowledge of coagulation and embolism was gained. Prevost and Dumas (1821) found that exsanguinated animals could be revived by the transfusion of blood, while the injection of serum or water was without effect. Blood from animals of another species was only temporarily efficacious. Defibrinated blood and blood which had been standing were found to be as beneficial as was fresh, whole blood.

physiologist and obstetrician, James Blundell (1790–1877). Appalled by his helplessness in the face of overwhelming hemorrhage, his mind turned again toward the direct expedient of returning blood to the exsanguinated organism. He subjected the question to careful scientific experimentation, and found that death from hemorrhage could be prevented by the transfusion of blood from animals of the same species, even after all signs of life had disappeared. Blood from animals of another species was unsuitable, since the resuscitation it effected was followed by death after several days. For human transfusion, therefore, he declared that only human blood was fit to be used. Direct transfusion required an operation upon the artery of the donor which was, in those days, a formidable procedure. Blundell, therefore, studied the effect of passing blood through a syringe. He found that it lost none of its life-giving properties by such handling. To obviate the necessity of cannulating the vein of the donor, he devised a three-way syringe similar to those in use today. This, and his later instruments, the "Impellor" and the "Gravitator" were the first of a long series of devices invented for the indirect transfusion of blood.

"With a mind rationally prepared to the best of my power by previous reflection and experiment," Blundell applied the results

firm clinical basis with rational indications and a scientific background. Moreover, he introduced methods which find their ex-

Fig. 2. Early conceptions of animal and human blood transfusions. Mercklin, 1679.

of his studies to the human body, and to him belongs the credit of performing the first transfusions with human blood. His first four attempts were desperate resorts in dying patients, and all failed. Convinced by his experiments, however, that he must succeed, he persevered, and was eventually able to resuscitate several women when death from postpartum hemorrhage seemed certain. He performed the operation eleven times, a number greater than that of any of his predecessors. He succeeded not only in bringing the operation of transfusion back into notice, but also in placing it upon a

pression in some of the common technics employed today.

Following the example of Blundell, a certain number of transfusions were done in England and on the continent. Its indication in the treatment of hemorrhage, particularly that following childbirth, had been established. It was an operation to be performed, however, only as a last resort. Donors were scarce. Phlebitis and sepsis, in both recipient and donor, were constant dangers. Reactions were frequent, and sometimes death occurred even when human blood was used. Furthermore,

technical difficulties were numerous, particularly those due to coagulation of the blood.

FIG. 3. Lamb blood transfusion. Purmann, 1684.

Knowledge toward the control of these difficulties was slowly acquired. Creite (1869) described the clumping of red blood corpuscles of man when placed in the sera of animals. Landois (1875) elaborated these experiments and found that serum of one species agglutinated and dissolved the corpuscles of other species. These investigations led more and more strongly to the conviction that the transfusion of foreign blood was dangerous, and that only human blood should be used. Defibrination of blood to prevent coagulation, and admixture with phosphate of soda to retard clotting were introduced.

Toward the end of the third quarter of the nineteenth century, the growing interest in blood transfusion culminated in a wave of exaggerated enthusiasm, in which the procedure was heralded as "ushering in a new era in medicine." With the increased popularity came a curious departure from the principles which had become firmly established during the years. Instead of limiting the operation to cases of anemia or acute hemorrhage, it was applied to a host of vague infectious and debilitating diseases, as well as to the "burnt, the uremic,

the syphilitic and the mad." In spite of the frequently demonstrated dangers and disadvantages of heterologous transfusions, animal blood was again widely used. At the Congress of the German Surgical Society of 1874, there was a report of thirty-one sheep blood transfusions.

The efficacy of physiological salt solution infusions for the treatment of shock and acute anemia was demonstrated about this time (1875 to 1880). Its superiority over blood transfusion was unquestioned; donors were unnecessary, the technic was simple, the solution did not coagulate during its administration, and above all, it was safe. It rapidly supplanted blood transfusion and the latter operation was, therefore, once more virtually abandoned, this time not to be seriously taken up again until the beginning of the present century.

In this interval, modern surgery was born. Bacteriology became established as a science and asepsis came to surgery. With this, the danger of infection during transfusion fell away. The daughter science, immunology, was growing rapidly. In the year 1900, Landsteiner made the momentous discovery which subsequently won for him the Nobel Prize, that human blood contains isoagglutinins capable of agglutinating other human red blood corpuscles; and that human bloods were divided into three groups with reference to their agglutinating reactions. He recognized the significance of these findings in explaining the mysterious reactions which so often followed in the wake of blood transfusions. Decastello and Sturli, in 1902, added the fourth blood group. Hektoen (1907) urged that agglutination reactions be made the basis for the selection of donors for transfusion, and presented a simple method for determining the blood groups. In the following year, Ottenberg applied these important immunological discoveries in transfusion practice, and he subsequently showed that fatal reactions could be avoided by the use of compatibility and typing tests. The universal adoption of

these tests in the selection of blood donors has eliminated the last great danger in blood transfusion, and has made its modern widespread application possible.

transfused; there was danger to the donor in infectious cases, and mishaps due to the clotting of blood or the severing of the anastomosis by motion on the part of

FIG. 4. Transfusion with Blundell's "Gravitator," 1628.

The remaining difficulties to be met were of a technical character, and these were largely overcome during the first quarter of the present century, with the development of several safe and simple methods of transfusion. At the beginning of this period, transfusions were done by the direct anastomosis of the vessels of donor and patient. Carrel perfected his method of blood vessel anastomosis in 1905, and for several years transfusions were done by uniting the artery of the donor with the vein of the recipient by suture. This necessitated a formidable operation and a delicacy of technic that limited its use to accomplished surgeons who were experienced in blood vessel surgery. Crile, in 1907, introduced his method of cuffing the artery back over a cannula and tying the vein over it. This greatly facilitated the operation and, together with its many modifications (Elsberg, Jeger, Soresi), was the preferred method for some time. To simplify the procedure further, recourse was again had to the simple cylindrical cannula (Brewer, Morel), similar to those used by Lower and Denis in the earliest transfusions.

All of these methods of direct transfusion, however, required the sacrifice of an artery of the donor. Moreover, it was impossible to measure the amount of blood

either patient or donor were distressingly frequent. Consequently, with the advent of simple and reliable indirect methods of transfusion, these direct ones were more and more neglected until, today, they are entirely obsolete.

It had been shown by Bordet and Gengou, in 1901, that clotting of blood could be delayed if it came into contact only with surfaces that had been coated with paraffine. Curtis and David made use of this principle in 1911, in an apparatus consisting of a paraffine-lined vessel having two outlets and connected with a syringe. Through one of these, blood was aspirated from the donor; through the other, it was injected into the patient. Two years later, Kimptom and Brown utilized the same idea in their paraffine-coated tube, which was subsequently modified by Percy, Vincent and Schlaefer, and which is still occasionally used today.

. In the same year (1913) Lindeman revived a method described by Ziemssen in 1892, consisting of the use of multiple large syringes which were successively filled from a cannula in the vein of the donor and emptied through a second one in the vein of the recipient. Unger (1915) devised a four-way valve syringe attachment in which there were outlets to donor and recipient, and one to a reservoir containing

saline or citrate solution. There have been innumerable variations on this principle, and they continue to appear in an uninterrupted stream. Various types of cocks and

stated, attempts had been made for the past one hundred years to render blood incoagulable by physical and chemical treatment. The transfusion of defibrinated

FIG. 5. Transfusion with Aveling apparatus, 1863.

valves have been devised to insure the success and safety of the transfusion. Practically all of the unmodified blood transfusions today are done by one or another of these methods.

Two departures are sufficiently different in principle to warrant mention. In the tradition of the paraffined tube, attempts have been made to construct transfusion instruments of amber or plastic materials, in order to delay coagulation within the apparatus. Neubauer and Lampert[2] initiated this principle, and it has found considerable application, chiefly in Germany. Erb[3] and Buerkle-de la Camp[4] have devised instruments of amber and of "athrombit," a plastic substitute for amber. The other modification is the use of milking devices in which the blood is forced by various types of rollers, through rubber tubing, thus coming into contact with no other surface. The first of the instruments of this type was introduced by Beck,[5] in Germany. Subsequently, Henry and Jouvelet[6] in France, and DeBakey,[7] Baker,[8] and Pennell,[9] in this country have utilized this idea in various forms.

The greatest source of difficulty with these and the previously mentioned methods of transfusion was the clotting of blood within the apparatus. As has been

blood was largely abandoned following the work of Koehler in 1877, who demonstrated that blood so treated contained an excess of fibrin ferments which exerted a hemolytic action on the cells of the recipient, and which were also potentially capable of initiating coagulative changes. It has since been pointed out that many of the reactions formerly attributed to defibrination were actually due to the use of incompatible bloods. Sporadic efforts are made, even today, to revive the use of defibrinated blood transfusions.

Landois (1892) suggested the use of hirudin to keep blood from clotting during transfusion, but it was difficult to obtain sufficiently pure and reliable preparations of the drug, and the range between effective and toxic doses was too narrow. Hustin, of Belgium, in 1914, reported his experiments on the use of sodium citrate and glucose to prevent coagulation. In the following year, Agote, of Buenos Aires, and Lewisohn in this country independently advocated the use of sodium citrate alone to prevent blood from clotting during transfusion. This discovery revolutionized the practice of blood transfusion. It became simple, safe and certain, and rapidly grew in popularity until its present widespread adoption was attained.

The one factor delaying the wider application of the citrate method of transfusion was the incidence of pyrogenic reactions. These were at first thought to be inherent in the method. Lewisohn and Rosenthal have since shown that chill reactions are always due to protein material derived from impurities in the apparatus or solutions. Careful elimination of such impurities enables the reduction of chill reactions to an incidence comparable with that of whole blood transfusions. Since then, there has been a wide swing back to citrate transfusions in civil and, particularly, in military practice.

NEWER DEVELOPMENTS IN BLOOD TRANSFUSION

Most of the recent innovations in blood transfusion are derivatives of the citrate method. Credit is due the Russian investigators for the energy, courage and ingenuity they have exhibited in their developments in the field of blood transfusion. The trend has been toward methods which make for wider applicability and obviate time loss in emergency situations. Preserved blood transfusions lend themselves admirably toward the achievement of these purposes, and much of the recent work has to do with the use of stored blood or blood constituents.

The transfusion of conserved blood is not new. Rous and Turner[10] showed in 1916 that blood could be preserved for prolonged periods without loss of viability of the erythrocytes. This method was applied during the World War by Robertson,[11] of the United States Army Medical Service, who used blood as old as twenty-six days. Preserved citrated blood was used by the Loyalist forces during the Spanish Civil War and was introduced into civil practice by the Russian workers. Its sudden popularity and wide adoption in this country and parts of Europe date from the initiation of the "blood bank" at the Cook County Hospital by Fantus and his coworkers.[12]

The advantages of preserved blood transfusions are obvious. Valuable time is saved

in emergencies, seeking compatible donors. There is vast economy of time and effort, and more blood becomes available for

Fig. 6. Capillary blood transfusion, Gesellius, 1868.

transfusion. The relative safety and effectiveness of preserved blood is still being investigated. The consensus of opinion thus far is that blood is satisfactory for transfusion if not kept too long. Changes become demonstrable after five to ten days which render it unfit for transfusion.

Cadaver Blood Transfusions. The use of cadaver blood for transfusion is also a Russian conception. These workers found that blood taken from fresh corpses retained its function and viability. Subsequently, in 1934, they reported that in cases of sudden death, the blood clotted promptly after its removal from the body, and later returned to the fluid state and remained incoagulable. This process of fibrinolysis rendered the addition of anticoagulants superfluous. The clinical use of

cadaver blood for human transfusions was introduced by Yudin[13] who, in a series of publications, has reported satisfactory results in a large number of cases.

Whether because of fear or sentiment, acceptance of cadaver blood transfusion has been extremely reluctant in countries outside of Russia. It is more than possible, however, that in times of war when sentiment, perforce, goes by the board, when the needs for donor blood may reach staggering proportions, and when there is no lack of corpses due to sudden violence, that the use of cadaver blood for transfusion may be generally adopted.

Placental Blood Transfusions. The expedient of using placental blood for transfusion appears to have occurred independently to a number of workers in different countries. Perhaps the earliest reference to placental blood transfusion is by Ascoli and Vercesi from Italy, in 1934. The Russian investigators published their first series of 114 placental blood transfusions in 1936. Goodall and his collaborators[14] advocated the use of placental blood on this continent in 1938, since which time there has been a moderate display of interest in this source of blood for transfusion.

Serum and Plasma Transfusions. Serum or plasma has been used sporadically over a long period of time, as a substitute for whole blood. Recently Strumia and his coworkers[15] and Levinson, Neuwelt and Necheles[16] have convincingly demonstrated the efficacy of these blood constituents, particularly in the treatment of shock. They possess two outstanding advantages: They can, apparently, be preserved for indefinite periods without deterioration, and they may be used without preliminary typing or compatibility tests. They may thus be kept in operating or delivery rooms, ready for immediate injection when emergency need arises.

CONCLUSIONS

Blood transfusion has had a long and interesting history. The idea of restoring blood to the depleted and exsanguinated organism appealed quite naturally, long before the risks and difficulties attendant upon blood transfusion were known. As a result, there have been alternate periods of enthusiastic acclaim and of complete neglect. Pasteur and Lister pointed the way toward the conquest of infection, the first great danger. Reactions from incompatible bloods were eliminated by the application of Landsteiner's discovery of the isoagglutinins. The modern era in blood transfusion has taught technical methods that permit the safe, simple and certain transference of blood from donor to patient.

REFERENCES

1. For bibliography the reader is referred to an earlier publication, ZIMMERMAN, L. M. and HOWELL, K. M. History of blood transfusion. *Ann. Med. Hist.*, 4: 415–433, 1932.
2. NEUBAUER, O. and LAMPERT, H. Ein neuer Bluttransfusions-apparat. *München. med. Wchnschr.*, 77: 582–586, 1930.
3. ERB, K. Bernstein-Bluttransfusionsapparat mit neuem Prinzip der Mechanik bei der Blutuebertragung. *Arch. f. klin. Chir.*, 186: 212–215, 1936.
4. BUERKLE-DE-LA CAMP, H. *Zentralbl. f. Chir.*, 58: 854–856, 1931.
5. BECK, A. Die Methodik der Bluttransfusion und die Vermeidung ihrer Gefahren. *Ergebn. d. inn. Med. u. Kinderh.*, 30: 150–220, 1926.
6. HENRY and JOUVELET, Appareil à transfusion du sang. *Presse méd.*, 42: 828–829, 1934.
7. DE BAKEY, M. A simple continuous-flow blood transfusion instrument. *New Orleans M. & S. J.*, 87: 386–389, 1934.
8. CASHMAN, B. Z. and BAKER, M. H. Massive blood transfusions during abdominal operations. *Am. J. Obst. & Gynec.*, 31: 240–252, 1936.
9. PENNELL, S. A new type of blood transfusion apparatus. *Am. J. Surg.*, 45: 354–356, 1939.
10. ROUS, P. and TURNER, J. R. The preservation of living red blood cells in vitro. *J. Exper. Med.*, 23: 219–237, 1916.
11. ROBERTSON, O. H. Transfusion of preserved red blood cells. *Brit. M. J.*, 1: 691–695, 1918.
12. FANTUS, B. Blood preservation. *J. A. M. A.*, 109: 128–131, 1937.
13. YUDIN, S. S. Transfusion of cadaver blood. *J. A. M. A.*, 106: 997–999, 1936.
14. GOODALL, J. R., ANDERSON, F. O., ALTIMAS, G. T. and McPHAIL, F. L. An inexhaustible source of blood for transfusion and its preservation. *Surg., Gynec. & Obst.*, 66: 176–178, 1938.
15. STRUMIA, M. M., WAGNER, J. A. and MONAGHAN, J. F. The use of citrated plasma in the treatment of secondary shock. *J. A. M. A.*, 114: 1337–1341, 1940.
16. LEVINSON, S. O., NEUWELT, F. and NECHELES, H. Human serum as a blood substitute. *J. A. M. A.*, 114: 455–461, 1940.

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